

CWM CHEMICAL SERVICES, INC.

CHICAGO INCINERATOR FACILITY
CHICAGO, ILLINOIS

FINAL
RCRA FACILITY INVESTIGATION
REPORT

- PART 1: FACILITY INVESTIGATION**
PART 2: EVALUATION OF CORRECTIVE
MEASURE TECHNOLOGIES
PART 3: INVESTIGATION ANALYSIS

VOLUME 1 OF 5

FEBRUARY 1995



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

REPLY TO THE ATTENTION OF:

THESE ATTACHMENTS TO THE FINAL CWMCS CHEMICAL SERVICES INC. RFI REPORT (VOL. 1-5) IS AN ISSUES DOCUMENT THAT PROVIDES A DISCUSSION ON SIGNIFICANT DEFICIENCIES, CONCERNS AND UNRESOLVED ISSUES, FROM SEVERAL EFFORTS TO DEVELOP A FINAL RFI REPORT, THAT REFLECTS THE TECHNICAL AND PRACTICAL REALITIES OF THIS SITE. THE FINAL RFI REPORT CONTAINS THE SUBSTANTIVE DISCUSSION OF VARIOUS ISSUES SURROUNDING INVESTIGATIONS CONDUCTED AT THE CWMCS SITE. U.S. EPA DISAGREES WITH SIGNIFICANT PORTION OF THE FINAL RFI REPORT. THE FINAL RFI REPORT IS DEFICIENT IN SEVERAL AREAS AND U.S. EPA HAS DECIDED NOT TO FOLLOW SOME OF THE RECOMMENDATIONS IN THE REPORT BASED ON AN ANALYSIS OF SPECIFIC SITE CIRCUMSTANCES. THE FINAL RFI REPORT WAS NOT REVISED AS REQUESTED BY U.S. EPA.



ATTACHMENTS

- 1) May 3, 1995 letter and attachment 1;
- 2) February 27, 1995 letter;
- 3) January 5, 1995, letter and attachments 1 & 2.

MAY 03 1995

HRE-8J

Mr. Kevin K. Hersey
CWM Chemical Services, Inc.
3001 Butterfield Road
Oakbrook, Illinois 60521

Re: Final CMS determination
CWM Chemical Services Inc.
ILD 000 672 121

Dear Mr. Hersey:

The United States Environmental Protection Agency (U.S. EPA) is in receipt of your March 27, 1995, letter concerning the facility at 11700 South Stony Island, Chicago, Illinois. This letter was in response to U.S. EPA's February 27, 1995 preliminary written determination that a Corrective Measures Study (CMS) is required at the CWM Chemical Services, Inc. (CWMCS) facility pursuant to Section IV, Part (H) of the 1988 Consent Judgement (CJ).

On March 6, 1995, U.S. EPA received CWMCS's Final RCRA Facility Investigation Report (RFI). U.S. EPA has completed reviews of the final RFI report and your response to the preliminary written determination for a CMS. As per a January 5, 1995, letter and attachment, U.S. EPA continues to hold its same position that CWMCS' final RFI report is deficient in several areas. The final RFI report was not revised as required by the CJ. U.S. EPA disagrees with a significant portion of the RFI report. Pursuant to section IV, Paragraph (I) of the CJ, U.S. EPA is required to make a final written determination as to whether a CMS is required at the CWMCS facility and provide a copy of this written determination to CWMCS. Based upon the information of record, U.S. EPA has determined that a CMS must be performed at the above-mentioned facility.

In your March 27, 1995, response, you have identified four issues you believe are relevant to a CMS determination. By this letter, and the enclosed attachment, U.S. EPA is providing the basis for making a determination that a CMS is necessary at the CMS facility pursuant to Section IV, Paragraph (I) of the CJ. U.S. EPA also hereby responds to the four issues in your March 27, 1995, letter that you have identified as relevant to the CMS determination. Finally, this constitutes U.S. EPA's final written determination that a CMS is necessary at the CWMCS facility located on 11700 South Stony Island, Chicago, Illinois.

-2-

If you have any questions regarding this matter please contact Mr. Jonathan Adenuga of my staff at (312) 886-7954.

Sincerely yours,

ORIGINAL SIGNED BY
JOSEPH M. BOYLE

Joseph M. Boyle, Chief
RCRA Enforcement Branch

cc: Kostas Dovantzis, PRC

bcc: Tom Tuner, ORC

HRE-8J/JA/be/5/1/95/6-7954/Filename:CMSLTRFN

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ATTACHMENT 1

FINAL DETERMINATION REGARDING THE NEED FOR A CORRECTIVE MEASURES STUDY CHEMICAL WASTE MANAGEMENT - CHEMICAL SERVICES, INC. CHICAGO INCINERATOR FACILITY

SAND SEAMS ISSUE

CWMCS states that the information submitted to EPA indicates that sand seams in the upper and lower lacustrine layers are discontinuous and that the focus of the CMS will be on the unconsolidated unit overlying the upper lacustrine layer. Given the depth and frequency of contaminant occurrence, it may be appropriate to focus the CMS on the unconsolidated unit. As was indicated in U.S. EPA's January 5, 1994, letter, the issue regarding whether sand seams in the lower lacustrine layer are discontinuous should be deferred. It is also well documented in the Final RFI report that migration pathways to the lake exist, and that the upper lacustrine layer, the unconsolidated unit, and groundwater beneath the facility are contaminated with metals, volatile organic compounds (VOCs), and semi volatile organic compounds (SVOCs). In addition to the migration pathways and contaminants, adjacent lake sediments are also contaminated. As long as these contaminated media and all migration pathways to the Lake are addressed in the CMS, the issue of discontinuous sand seams in any of the geologic units beneath the CWMCS facility will become moot.

RISK ASSESSMENT ISSUE

In your response, you indicate that CWMCS submitted a Human Health Risk Assessment (HHRA) as an appendix to the RFI report and that in lieu of commenting on the HHRA report, U.S. EPA directed its consultant to prepare a supplemental HHRA (SHHRA). You further state that U.S. EPA demanded that the SHHRA information be incorporated without correction into the RFI report and that, to this date, U.S. EPA failed to identify the serious shortcoming, when in fact it has. CWMCS also states that it recommends that the SHHRA be withdrawn because U.S. EPA assumed in the SHHRA that commonly employed personal protective equipment (PPE) would not be employed at the facility.

Your description of the chronology of events regarding the risk assessment issue is inaccurate and unresponsive to the actual record of events, which includes your response to U.S. EPA's comments on CWMCS base line Risk Assessment (RA)). In U.S. EPA's March 1, 1991, letter to CWMCS, item 4 specifically requested that CWMCS conduct a full-fledged risk and environmental assessment that is consistent with Task III.D of the Scopes of Work, Attachment A of the C.J. The CWMCS RA report was submitted

to U.S.EPA on December 6, 1993. CWMCS also requested that this RA report be considered as draft because CWMCS has identified several inconsistencies in its own report and data.

Prior to the U.S. EPA's June 3, 1994, letter and comments on CWMCS RA report, and based on reviews of the hard-copy and digitized CWMCS's RA data, U.S. EPA identified two potential receptors (i.e. remediation onsite workers and subsistence fishermen) that were not evaluated in the CWMCS RA. U.S. EPA had previously notified CWMCS of these deficiencies during a December 29, 1993, telephone conversation. During that conversation, CWMCS indicated that these potential receptors were not necessary and should not be included in the RA. U.S. EPA disagreed with CWMCS's position on this issue. CWMCS was then informed that U.S. EPA will be evaluating the risk to these two potential receptors and the results would be incorporated in the RA.

Consistent with U.S. EPA's policy regarding conducting full-fledged risk assessments, U.S. EPA supplemented the CWMCS risk data in the RA report, after CWMCS declined to evaluate risks to the above-mentioned two potential receptors. U.S. EPA prepared an additional risk assessment to compensate for the deficient and incomplete RA. Based on the findings of the SHHRA, construction and utility workers are assumed to be exposed to a significant carcinogenic risk (in excess of 10^4) in the eastern fenced area of the facility that includes the former biobed area; and remediation workers can be assumed to employ PPE because their work must be performed in accordance with a health and safety plan (HSP). However, it is not commonly assumed that typical construction and utility workers wear PPE for routine underground construction or repair activities. Therefore, the SHHRA must remain an integral part of the HHRA and the final RFI report.

Finally, your August 19, 1994, response to U.S. EPA's June 3, 1994, comments on the CWMCS RA report clearly indicate that U.S. EPA prepare the SHHRA only after furnishing comments on the CWMCS HHRA. Attachment II of the August response refers to U.S. EPA's comments on these two potential receptors that were not evaluated in the CWMCS baseline HHRA.

SURFACE WATER and SEDIMENT IMPACT ISSUE

CWMCS states that very little contamination was found in surface water and that no significant risk may exist from exposure to sediment under the exposure scenarios considered in the SHHRA. CWMCS further states that surface water and sediment are outside of the scope of the CMS.

U.S. EPA has re-evaluated the CWMCS's Final RFI report and your response to the preliminary determination. We agree with the general concept of focusing the CMS on contaminated soils and groundwater within the pier. However, this idea does not preclude the need to remediate contaminated sediments, which likely resulted from hazardous waste management activities at the CWMCS facility. As was indicated in the table (Attachment II) of January 5, 1994, comment letter, Polycyclic Aromatic Hydrocarbons (PAHs) in sediments of sampling location S-1 identified in the Final RFI report (Table 4-36) exceed the benchmarks for individual and total PAHs as established in the "Guidance for Protection and Management of Aquatic Sediment Quality in Ontario" and "National Oceanic & Atmospheric Administration" and U.S. EPA Sediment Quality Criteria. Your explanation of the ubiquitous nature of PAHs are reasonable when applied to the entire Lake Calumet region. However, Contaminated sediments, in close proximity to the facility, most likely resulted from waste management areas within the facility. The CMS portion addressing surface water and sediments should focus on remediating only those contaminated sediments that have been identified during the RFI. In addition, the following items below support U.S. EPA's position that these sediments and the Lake waters must be protected from further degradation:

- Multitude of contaminants detected in the groundwater continues to discharge to the Lake based on the facility's hydrogeologic conditions;
- Two major dissolved groundwater plumes exist for various volatile organic compounds (VOCs). The dissolved VOC plumes such as benzene, 1,1-dichloroethene, phenol, 2,4-dichlorophenol and semi-VOC naphthalene slowly discharge to the lake and degrade the lake water quality long term and degrade the sediment quality short term;
- Though diluted in the lake water U.S. EPA's and CWMCS's flux calculations show that contaminants discharge to the lake, thus degrading lake water quality and;
- The integrity of the onsite vault liner as a barrier preventing migration of leachate from the vault to the lake or infiltration of groundwater into the vault is questionable.

VAULT, G-349 and OTHER AREAS

CWMCS states that the CMS should address the entire facility using a single or multiple options.

U.S. EPA agrees that a single or multiple remediation alternatives may be appropriate for the entire facility as long as all contaminated areas and media are adequately addressed.

Soil and groundwater contamination should be addressed for all solid waste management units investigated during the RFI, including but not limited to the vault, monitoring well G-349, former biobeds, and the Hyon tank farm area.

In summary, based on the results presented in the final RFI report, EPA's evaluation of that report, and the foregoing discussion, the scope of the CMS should address contaminated soils and groundwater in the unconsolidated unit overlying the upper lacustrine layer. As shown in Part 1, Sections 4.2 and 4.3, and Part 3 of the final RFI report, soil and groundwater contamination in this unit exceeds both background levels and applicable regulatory levels for protection of Class II groundwater in the State of Illinois. In addition, as shown in Part 1, Section 4.2, and as determined by EPA's evaluation of the final RFI data, groundwater in the unconsolidated unit is hydraulically connected to and discharges a multitude of contaminants to Lake Calumet. Therefore, soil and groundwater, including contaminated sediments, remediation should be addressed in the CMS for all relevant areas. Institutional controls restricting underground construction and utility work as discussed above should be an integral part of correction measures for the facility.



Chemical Waste Management, Inc.

3001 Butterfield Road
Oak Brook, Illinois 60521
708/218-1500

February 27, 1995

FOR DELIVERY BY MESSENGER FEBRUARY 27, 1995

Mr. Jonathan Adenuga
Technical Enforcement Section 2
United States Environmental Protection Agency
RCRA Enforcement Branch, HRE-8J
77 West Jackson Boulevard
Chicago, Illinois 60604-3590

Re: **CWM - Chemical Services, Inc. (CWM-CS)**
ILD 000 672 121
RFI Project Coordinator/HRE-8J

Dear Mr. Adenuga:

Five (5) sets of the five (5) volume Final RCRA Facility Investigation Report for the subject facility are enclosed. This document has been revised to reflect the amendments referenced in CWM-CS's August 19, 1994 letter to the Agency. Volume 5 of the Report provides a list of CWM-CS's issues which remain to be resolved with the Agency. The list consists of CWM-CS's responses to the Agency's June 3, 1994 and January 5, 1995 letters.

In accordance with Mr. Brian Clarke's, Chemical Waste Management, Inc. letter dated February 15, 1995 to Mr. Thomas Turner, U.S.EPA; CWM-CS considers that upon submittal of this document to the Agency, the Agency has made a preliminary, written determination as to the need for a CMS pursuant to paragraph IV(H) of the Consent Judgment. Within 30 days of this submittal date (February 27, 1995), CWM-CS shall submit written comments on the preliminary determination to U.S.EPA.

CWM-CS has devoted a significant amount of time to this project. The original workplan was submitted to the Agency in 1988 and a Final RCRA Facility Investigation Report was furnished in November 1993. When necessary CWM-CS undertook activities beyond the scope of the workplan to supplement the information being gathered. This effort resulted in the submission of a high quality document which required minimal revision to finalize.

Several major areas of concern exist and resolution of these issues is necessary to contribute to the utility of the document in the future. Below are some of the most significant issues that are worthy of note.

ISSUE: Sand Seams

In a April 6, 1993 letter, U.S.EPA comments: "U.S.EPA continues to maintain that CWM's conclusions that sand seams are discontinuous is not supported by variations of hydraulic conductivity alone and neither does lithologic variations as asserted by you." The Agency's position is most recently summarized in their January 5, 1995 correspondence. "U.S.EPA does not believe that CWMCS has provided enough data to conclusively support the hypothesis that sand seams are discontinuous."

Relevance:

The relevance and concern for resolving this issue at this phase of the project is to establish the scope of future activities.

Discussion:

CWM-CS never relied solely on variations in hydraulic conductivity or lithologic variations to conclude the sand seams are discontinuous. The Agency approved project workplan was followed and a major effort undertaken at CWM-CS's initiative to further define the sand seams. This information has been shared with the Agency and CWM-CS's August 19, 1994 response to the Agency provides five (5) pages of narrative detailing the basis for concluding the sand seams are discontinuous. It remains the professional opinion of CWM-CS's consultant, Dames & Moore, that the sand seams are discontinuous. The Agency's observations on this issue are generally non-specific.

Recommendation:

U.S.EPA should carefully consider the information that has been furnished on this issue. If specific shortcomings exist, they should be identified.

ISSUE: Supplemental Human Health Risk Assessment (SHHRA)

CWM-CS submitted a Human Health Risk Assessment as an appendix to the investigation report. The Agency prepared the Supplement Human Health Risk Assessment without furnishing comments on the Human Health Risk Assessment prepared by CWM-CS. The Agency's June 3, 1994 letter comments: "Our review of your January 11, 1994, Human Health Risk Assessment report have identified a very serious shortcoming." To this date the "very serious shortcoming" has not been identified.

Relevance:

The Agency's SHHRA assumes violation of good operating practices and violation of OSHA regulations to calculate a level of risk which is unacceptable to the Agency. Further concerns, such as the use of screening techniques to reach conclusions requiring more complex techniques, inconsistencies with other Agency comments, etc.; have been shared with the Agency and would require substantial revision to the SHHRA.

The Consent Order directs the Agency to furnish comments on CWM-CS's work product. In lieu of commenting, the Agency directed its consultant to prepare an important section of the investigation report and then demands that the information without correction be incorporated into the report.

Discussion:

CWM-CS has shared with the Agency concerns relating to the SHHRA. Specifically, the Agency's risk assumption requires that standard operating practices and OSHA regulations be ignored to achieve the level of risk indicated in the Agency's document.

The Agency, as recently as the January 5, 1995 correspondence, remains insistent that this document be included, without amendment, into the Final RCRA Facility Investigation report prepared by Dames and Moore.

Recommendation:

Assumptions in the Agency's SHHRA cannot be supported. Unfortunately, these assumptions are fundamental to the Agency's conclusions. CWM-CS recommends that the SHHRA be shelved.

ISSUE: Surface Water and Sediment Impacts

Investigation of surface water and sediment conditions at the facility were undertaken in accordance with the Agency approved work plan. This effort involved a two phase collection of water and sediments from Lake Calumet. The first phase broadly defined conditions while the second phase utilized the results of the first phase to focus on potential areas of concern.

Relevance:

This issue must be resolved to establish the scope for future activities.

Discussion:

A significant effort was undertaken to provide highly accurate analytical data for this program. A review of the CWM-CS data by the Agency's risk assessment contractor concluded that exposure to surface water was not evaluated primarily because very little contamination was detected in surface water during the RFI. Further, the risk assessor concludes that there may be no significant carcinogenic risk from exposure to sediment at the facility under the exposure scenarios considered. The Agency essentially agrees with this observation by concluding that contaminants are mostly not detectable by current technology due to infinite dilution.

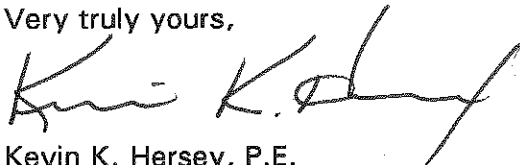
Recommendation:

Recognizing that the investigation involved assessing the impacts of contaminants placed in the pier area (immediately adjacent to Lake Calumet) approximately 20 years ago by previous facility operators, any discharge of materials to Lake Calumet that may be occurring is generally not measurable by current technology. Further there is no reason to believe that the conditions will deteriorate in the future. There is no reason to consider Lake Calumet as a part of any future CMS activity.

The foregoing represents major concerns associated with the Agency's observations and comments. These issues relate directly to establishing a CMS scope.

If additional information is required, please contact the writer at (708)218-1652.

Very truly yours,



Kevin K. Hersey, P.E.
Senior Environmental Engineer

KKH/ss
Enclosures

cc: Joseph Boyle / U.S.EPA w/o
Brian Clarke w/o
Jim Doyle w/o
Bob LaBoube w/o
Jules Selden/Clean Harbors
Dave Trainor Dames & Moore, Madison w/o
Tom Turner/ U.S.EPA w/o

JAN 05 1995

HRE-8J

Certified Mail
Return Receipt Requested

Mr. Kevin K. Hersey
CWM Chemical Services, Inc.
3001 Butterfield Road
Oak Brook, Illinois 60521

Re: Final RFI Report
CWM Chemical Services Inc.
ILD 000 672 121

Dear Mr. Hersey:

The United States Environmental Protection Agency (U.S. EPA) received your letter dated August 19, 1994, and the attachments. The letter was in response to U.S. EPA's June 3, 1994, comments on the CWM Chemical Services (CWMCS) November 3, 1993, Draft RFI Report. As properly characterized in your letter, the 1988 Consent Judgement does not stipulate that U.S. EPA approve CWMCS's RFI Report (REPORT). Pursuant to paragraph F of the Consent Judgement, after U.S. EPA provides written comments to CWMCS on any preliminary and final report, CWMCS shall amend the report to incorporate U.S. EPA's comments or CWMCS may request a meeting with U.S. EPA to discuss the comments.

On June 3, 1994, the U.S. EPA provided a written response to CWMCS's REPORT. Also, in the June 1994 letter and attachments, U.S. EPA requested that CWMCS amend the REPORT to incorporate all of U.S. EPA's revisions prior to finalizing the REPORT. On July 7, 1994, CWMCS met with U.S. EPA in Chicago to discuss the comments, and on August 19, 1994, you provided a written response (RESPONSE) to U.S. EPA's June 1994 comments. U.S. EPA has completed the review of your RESPONSE. We continue to disagree with a substantial number of items in the RESPONSE. Pursuant to paragraph F of the Consent Judgement, your RESPONSE constitutes the CWMCS' final discussion on U.S. EPA's comments, and adequately satisfies the provisions of paragraph F of the Consent Judgement. Therefore, within twenty one (21) days of receipt of this letter and attachments, CWMCS must now amend the REPORT, incorporating U.S. EPA's comments/revisions as outlined in the June 3, 1994, comments and submit the revised REPORT as the Final RFI Report. If CWMCS resubmits the November REPORT as the Final RFI Report without incorporating U.S. EPA's comments, U.S. EPA will attach a disclaimer to the REPORT, including this document and its attachments. The disclaimer would state that U.S. EPA disagrees with a significant portion of this report, that this Final RFI Report was determined to be deficient in several areas, and that it has not been modified as requested by U.S. EPA.

The U.S. EPA, in its earlier review of the available data in the REPORT, determined that there exists a sufficient threat to human health and the environment at the CWMCS facility to warrant a Corrective Measures Study (CMS). After carefully reviewing your current RESPONSE, and all available data, we continue to hold our same earlier position that a CMS must be conducted at the CWMCS facility. Finally, pursuant to paragraph H of the Consent Judgement, this letter constitutes U.S. EPA's preliminary determination that a CMS is necessary at the CWMCS facility located on 11700 South Stony Island, Chicago, Illinois.

If you have any questions regarding this matter please contact Mr. Jonathan Adenuga at (312) 886-7954 or Tom Turner at (312) 886-6613.

Sincerely yours,

Jonathan Adenuga
Technical Enforcement Section 2
RCRA Enforcement Branch

Enclosure

cc: Kostas Dovantzis, PRC

bcc: Tom Turner, ORC

HRE-8J:JA/be/6-7954/1/4/95/Filename:a:RFIAPRV.LTR

CONCURRENCE REQUESTED FROM REB			
SEC/BR SECRTRY	10/1/95		
OTHER STAFF	REB STAFF	REB SECTION CHIEF	REB BRANCH CHIEF

ATTACHMENT 1

U.S. EPA will not address each item in your RESPONSE but will address those items that are critical to the final RFI Report. The following are U.S. EPA's responses to comments on the August 19, 1994, cover letter:

- In item No. 6 of your letter, you state, "The REPORT is the product of CWMCS's consultant Dames and Moore. It is unreasonable to require comments and revisions to the REPORT that Dames and Moore either disagrees with or believe to be technically incorrect". U.S. EPA disagrees with you that our June 1993, comments and revisions to CWMCS REPORT are technically incorrect. The provisions of the 1988 Consent Judgement are binding upon all parties including your Consultant/Agent Dames and Moore. The U.S. EPA expect these revisions to the REPORT to be made by either CWMCS or its Agents.
- In item No. 4 of your letter, you state that the highest calculated cancer risk is based on a single compound found in a single sample collected from a single location. However, the procedure followed in the Supplemental Human Health Risk Assessment (SHHRA) in developing exposure point concentrations adheres to the most recent U.S. EPA guidance. Further, Section 5.0 of the SHHRA acknowledges that the calculation of upper-bound exposure point concentrations is one source of uncertainty that may contribute to the overestimation of risk. U.S. EPA believes that the risks presented in the SHHRA were calculated properly.
- In item No. 3 of your letter, you state that the goal of the risk assessment process is to evaluate risk and not establish a "firm basis for corrective action". Your characterization of CWMCS's risk evaluation at the facility is accurate. CWMCS's risk data was presented in the REPORT. However, U.S. EPA's evaluation of the risk data, found it lacking in some respect and in some instances, we have supplemented the CWMCS risk data in the REPORT by preparing an additional risk assessment to compensate for the missing information in the CWMCS Human Risk Assessment Report. After carefully reviewing CWMCS risk data and the supplemented data, U.S. EPA concluded that there is sufficient threat from the CWMCS facility to human health and the environment because contaminants discharge to the lake and groundwater contaminant levels exceed the applicable groundwater protection standards for class II groundwater. Also all future construction activities involving excavation will need to be done by workers wearing personal protective equipment. This conclusion was not based solely on risk data but also on other corroborative data in the REPORT.
- In item No. 2 of your letter, you state that U.S. EPA has ignored analytical data collected on surface water and sediments and has reached significant conclusions concerning the project by relying on flux

calculations. CWMCS stated that flux calculations for contaminant discharges into Lake Calumet were useful to help determine where samples should be collected.

U.S. EPA has not ignored surface water and sediment analytical data obtained during the RFI. CWMCS seems to have misinterpreted paragraph 3 of the June 3, 1994 letter. Paragraph 3 simply stated that U.S. EPA reached a conclusion after all of the information in the REPORT, including flux calculations and comparison of class II groundwater protection standards to onsite groundwater contamination levels, was evaluated and considered.

CWMCS's response is inconsistent with the agreement reached between U.S. EPA and CWMCS before preparation of the draft RFI report. Under that agreement, flux calculations were considered necessary to demonstrate the effect that groundwater contamination may have on human health and the environment. In fact, in the draft RFI report, CWMCS proposed that modeling and flux calculations be used to establish alternative groundwater concentration levels.

Finally, contrary to what is stated, these flux calculations were not voluntarily performed by CWMCS to determine where samples should be collected at the CWMCS facility. Rather, CWMCS agreed to perform these calculations after being requested to do so by U.S. EPA. The U.S. EPA and CWMCS have used modeling techniques to calculate the contaminant fluxes. These calculations are based on groundwater analytical data and hydrogeologic data obtained by CWMCS during the RFI. However, because contaminants discharging to the lake are infinitely diluted, the organics measured in surface water are mostly nondetectable. This finding is not at all surprising. On the other hand, both CWMCS and U.S. EPA calculations indicate that contaminants are discharged to the lake. However, CWMCS has failed to address the large number and concentrations of contaminants detected in groundwater that discharge to the lake based on the facility's hydrogeologic conditions. These contaminant discharges should be addressed in the CMS.

The following are U.S. EPA's responses to some of the critical items in Attachment 1 of your RESPONSE:

Part 1

- Item No. 1 concludes, "The presence of continuous or discontinuous sand seams in the lower lacustrine layer is not significant. The lower lacustrine unit is separated from the contaminated fill unit by the upper lacustrine unit. This unit is a homogeneous silty clay soil unit approximately 10 feet thick, in which no contaminants were measured in all soil specimens collected from this layer. Consequently, the unit behaves as a barrier to the migration of contaminants".

U.S. EPA does not believe that CWMCS has provided enough data to conclusively support the hypothesis that sand seams are discontinuous. However, to prevent any further delay in finalizing the RFI Report, the

issue regarding whether the sand seams encountered during these investigations are discontinuous should be deferred. CWMCS could state in the RFI Report that both the U.S. EPA and CWMCS disagree as to the status of the sand seams encountered during the RFI.

- In items 3a, 3c and 25, your responses indicate that the potentiometric surface maps correctly depict groundwater elevations in the vicinity of the vault and that the vault liner is a barrier preventing migration of leachate from the vault or infiltration of groundwater into the vault. Also, CWMCS does not agree that contaminants in monitoring wells G-302 and G-336 originate from the vault and maintains that these contaminants originate from solid waste management unit (SWMU) 6.

First, no as-built drawings of the vault are available to show how this vault was constructed. Second, the contaminants in wells G-302 and G-336 are likely a result of preferential migration of contaminants from the vault to the lake. CWMCS implies that similar contamination should have been found in well G-318, but this is not necessarily true because the vault's clay liner may be effectively containing migration in the direction of that well. U.S. EPA believes that the vault's integrity is questionable because of contaminants detected in adjacent downgradient wells G-302 and G-336 and because no construction records or data for the hydraulic head within the vault are available to substantiate CWMCS's statements. The vault may be reducing contaminant migration to the lake, but it does not prevent migration to the lake. As stated in CWMCS's response, leachate may have been generated from infiltrating precipitation, which implies that the vault's cap is permeable. The vault's sidewalls and bottom may also be permeable in certain locations, causing contaminants to slowly and erratically migrate toward monitoring wells G-302 and G-336. The vault area should be addressed in the CMS for the facility.

- In item No. 4, you state that after re-evaluating groundwater results, it was determined that inorganic compounds, including metals, do not indicate a contaminant distribution pattern. CWMCS states that it is impossible to determine if the onsite SWMUs or fill material are the sources of metals in the groundwater. CWMCS also states that the reason metals are not useful in identifying a contaminant distribution can be seen by comparing sample results from phase I and phase II.

U.S. EPA disagrees that inorganic compounds, including metals, do not indicate a contaminant distribution. U.S. EPA also evaluated all of the phase II groundwater sampling results in the REPORT, including soil sample results. A contaminant distribution pattern is still evident. The phase I sampling results were not evaluated because CWMCS has always insisted that the phase I results were unreliable.

- The response in item No. 5, indicates that contamination detected in well G-349 is from an upgradient source rather than from one of the

SWMUs investigated during the RFI. CWMCS is responsible for investigating the extent of contamination at the facility, and CWMCS should investigate whether a SWMU or other source on the facility caused this contamination. This source should be addressed in the CMS.

- In item No. 7, CWMCS states that groundwater sample results for wells located between the SWMUs and the lake do not support U.S. EPA's belief that groundwater moving through the fill is contaminating the lake. U.S. EPA does not agree. Evaluation of the RFI data indicates that contaminants detected at various monitoring wells screened adjacent to the lake and within the source areas of the facility migrate slowly from the facility to the lake. The contaminants are diluted in the lake but continue to deteriorate the lake's water quality.

- In items 8, 10 and 24, your responses indicate that U.S. EPA's flux calculations are simplistic and unrealistic. CWMCS also states that its calculation of contaminant fluxes using a "next-level-of-sophistication" model results in estimates of discharges that are one order of magnitude lower than those calculated by U.S. EPA.

U.S. EPA's calculations were intended to be simple in order to demonstrate the effect of facility contamination on the environment and to provide examples (such as for benzene, 1,1-dichloroethene, and vinyl chloride at three well locations) of the calculations that the RFI report lacked. U.S. EPA's calculations are realistic given the RFI data and the hydrogeologic conditions at the facility. CWMCS's complex model is in fact unrealistic given the facility conditions, and it yields results for the mass rate of discharge of benzene identical to those of U.S. EPA's simpler calculations. The U.S. EPA and CWMCS benzene flux results differ by an order of magnitude only because U.S. EPA's assumed area of contaminant discharge is an order of magnitude larger than CWMCS's. Even if an order of magnitude difference exists between the results of these calculations, it is not surprising given the variable hydrogeologic data presented in the RFI report. In any case, U.S. EPA and CWMCS flux calculations both indicate that contaminants discharge to the lake, thus degrading the lake's water quality, but CWMCS has not addressed discharges of the multitude of contaminants detected at high concentrations (relative to applicable groundwater protection standards) throughout the facility. These contaminant discharges should be addressed in the CMS.

- The response in item No. 26, does not address U.S. EPA's comment. The sentence "This contaminant distribution pattern of the fill sample is a reflection of groundwater sample results" should be rewritten as follows: The groundwater sampling results is a reflection of the contaminant distribution pattern in the soils and SWMUs at the facility.

- Your response in item No. 27, did not adequately address U.S. EPA's comment. CWMCS claimed that these PAHs are ubiquitous. On page 23,

paragraph 4, the text of Attachment I indicates that the major sources of polynuclear aromatic hydrocarbon (PAH) contamination are wind, scouring of the lake, and sediment transport by wave action. On page 21, paragraph 4, the text indicates that contaminants in sediments at sampling location S-1 are the result of precipitation runoff and industrial activities in the Lake Calumet area. These explanations are reasonable when applied to the entire area, but PAH contamination in sediments adjacent to the facility is more likely the result of runoff from waste management areas within the CWMCS facility. The contaminated sediments in close proximity to the CWMCS facility must be addressed regardless of whether these contaminants resulted from precipitation runoff. PAHs contaminants identified in the sediment samples also occur in high concentrations in the leachate samples collected from the onsite vault.

U.S. EPA have also compared the dry weight of the parameters found in the sediment sample at S-1 to conservative/screening benchmarks to determine if there is any potential for adverse ecological effects due to these sediment contaminants.

The benchmarks shown in the table (Attachment 1), are the lowest effect level (LEL) from the "Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario" (Persaud, et al.). The effects range median (ERM) is from the National Oceanic and Atmospheric Administration (NOAA) Technical Memorandum NOS OMA 52 (Long and Morgan), and U.S. EPA sediment quality criteria (SQC).

The dry weight ($\mu\text{g/g}$) of each parameter has been converted to the organic carbon normalized concentration ($\mu\text{g/g}_{\text{oc}}$) to facilitate comparison with the SQC benchmarks. Since no total organic carbon (TOC) value was provided with the data, the TOC was assumed to be 3% for the calculations done here. The conversion is

$$\mu\text{g/g} \div (\% \text{ TOC} \div 100) = \mu\text{g/g}_{\text{oc}}$$

$$10.1 \mu\text{g Phenanthrene/g} \div (3 \div 100) = 336 \mu\text{g/g}_{\text{oc}}$$

At sampling location S-1, all of the polycyclic aromatic hydrocarbons (PAHs) exceed the benchmarks for individual PAHs and total PAH. Phenanthrene exceeds the U.S. EPA sediment quality criteria. Based upon this review, further evaluation of the sediments in the proximity of sampling site S-1 is warranted to determine the level of risk to ecological receptors in the vicinity of the site.

Finally, U.S. EPA re-evaluated your response to your conclusion regarding the absence of "any discernable immiscible or dissolved contaminant plumes" originating from the CWMCS facility. We conclude, that your claim is incorrect. Volume 3, Appendix L of the RFI REPORT shows that two major dissolved groundwater plumes exist for various volatile organic compounds (VOC) during both phases of the RFI. One of these plumes encompasses the former biobed area and the Hyon tank farm area. The second plume emanates

from the wastewater basin west of the vault, which may be indicative of contamination emanating from the leachate vault. The dissolved VOC plumes depicted in Appendix L include organic compounds such as benzene, 1,1-dichloroethene, phenol, 2,4-dichlorophenol and the semivolatile compound naphthalene. In addition a dissolved arsenic plume is also evident for phase 1. Other plumes are also likely to exist, because the number of organic compounds detected in the onsite groundwater monitoring wells and soils is greater than the number of compounds depicted in Appendix L.

In addition, immiscible contamination such as floating oil and solvent mixtures was observed during field sampling at various locations, particularly adjacent and west of the leachate vault and in the biobed area. Evaluation of the RFI data indicates that these plumes slowly discharge to Lake Calumet and therefore degrade Lake water quality in the long term. Therefore, corrective measures to alleviate contaminant discharges to the lake are necessary and must be addressed in the CMS.

- The response in item 28, seems to imply that there are risks from Lake Calumet to recreational users and from fish ingestion. However, dermal absorption or incidental ingestion and fish ingestion are not viable pathways. CWMCS has not clearly defined these risks from Lake Calumet or the source(s) and the appropriate pathways associated with these risks. More importantly, CWMCS must explain any correlation between these risks, if any, and the management of hazardous waste at the facility if any. It has been documented in the REPORT that the groundwater in the fill is highly contaminated and the majority of the hazardous constituents in the groundwater are expected to be released to the lake. U.S. EPA also is aware that it may be difficult to quantify risk from fish ingestion due to the industrial activities within the Lake area.

Part 3

- In item No. 1, the response states that U.S. EPA's conclusion that it is necessary and practical to restore damaged areas to original condition or as close as possible is irresponsible and unsupported by a technical justification particularly without the benefit of a CMS. To reiterate, the purpose of the RFI is to determine the nature and extent of releases of hazardous waste or hazardous constituents from regulated units, SWMUs and other source areas at the CWMCS facility, and to gather all necessary data to support a CMS and if necessary to remedy these releases. The data and conclusions, as established in the REPORT, to a large extent corroborate and support U.S. EPA's position that the groundwater and soils at the CWMCS facility are highly contaminated and, as such, must be remediated. In addition, soil samples adjacent to the facility were also analyzed and found to contain hazardous constituents. The CMS should now contemplate proposals to remedy these releases. It is not irresponsible to require CWMCS to remedy these releases. Section 3008(h) clearly authorizes U.S. EPA to require corrective action or any other response necessary for any releases of hazardous waste from a facility to protect human health and the environment.

- The response in item No. 2, does not address U.S. EPA's comment. U.S. EPA requested that the CMS consider soil cleanup levels protective of groundwater quality standards found in 35 Illinois Administrative Code (IAC) Subpart B, Sections 620.10 and 620.20. However, CWMCS's response does not address this issue. In addition, on-site monitoring well data should be compared to Class II groundwater protection standards and upgradient monitoring well data to establish whether significant contaminant releases from the facility to groundwater have taken place.

The following are U.S. EPA's response to Attachment II in your RESPONSE:

- In item No. 6, U.S. EPA acknowledges the existence of Occupational Safety and Health Administration (OSHA) rules and regulations that require the use of personal protective equipment (PPE) to limit or prevent exposure to hazardous contamination. U.S. EPA does not condone or encourage any violations of these rules and regulations. However, in almost any industrial situation instances may arise in which PPE is not used or PPE is damaged, resulting in exposure to contamination. At a minimum, the baseline RA report should acknowledge that the use of PPE is not foolproof and that exposure to contamination may occur despite attempts to follow OSHA rules and regulations.

- In response to item No. 11, Section 5.7.4 of U.S. EPA's *Risk Assessment Guidance for Superfund* (RAGS) indicates that, in general, anthropogenic background chemicals should not be eliminated from the baseline RA because it is extremely difficult at the baseline RA stage to conclusively show that such chemicals (in this case, trichloroethene) are not related to the facility or the surrounding area. Furthermore, trichloroethene was detected in surface soil. It is difficult to imagine how trichloroethene, a volatile organic compound, migrated onto the facility solely from an off-site location and remained on the facility at a concentration high enough to be detected during sampling. The presence of trichloroethene in the surface soil suggests a more immediate and localized source of the contamination. Because the presence of trichloroethene in the surface soil at the facility cannot be attributed solely to off-site sources, the baseline RA report should justify the exclusion of trichloroethene as a contaminant of potential concern based on anthropogenic considerations.

- In item No. 31, your response misses the point of U.S. EPA's original comment. The comment was not referring to resuspension of dust from workers' skin and subsequent inhalation; rather, the comment was referring to the possibility that some of the contaminated dust could be inhaled at the same time that the dust is being deposited on workers' skin. Specifically, the baseline RA report should evaluate the potential for total exposure to fugitive dusts. Also, the baseline RA is supposed to consider reasonable maximum exposure (RME) conditions. Under such conditions, it is reasonable to assume that hygiene practices are not completely followed. Many industrial workers who work out of doors do not have well washed hands; thus these workers may be exposed

to contaminated soil via incidental ingestion of soil. The baseline RA should evaluate the potential for exposure to contaminated soil via incidental ingestion.

The following are U.S. EPA's comments to Attachment III in your RESPONSE:

- In item 1, you stated that it is outside the scope of the ERA report to compare the contaminants detected in surface water and sediment samples to those detected in samples collected at the facility. Because the source of pollutants in Lake Calumet is pertinent to the ERA and because the ERA report discusses the possibility that other sources are responsible for the contamination, some reference to on-site sample results is needed. Although a detailed discussion may not be necessary, at a minimum the ERA report should state whether some or all of the contaminants were also detected at the facility and should refer to another part of the RFI report where this comparison is made.
- In item No. 2, you stated that a survey conducted by Dames & Moore on September 27, 1993, will be referenced to support the conclusion that no threatened or endangered plant and animal species are present at the facility. This response partly addresses U.S. EPA's comment, but additional information is needed to substantiate CWMCS's conclusion. Information on specific areas at the facility, the methods used to conduct plant and animal surveys, and the conditions at the facility during the surveys (including weather conditions, other types of activities that were being conducted, and so on) should be provided.
- In addition, other supporting references are needed to determine whether threatened or endangered species (state-listed as well as federally designated) occur at the facility. The local office of the U.S. Fish and Wildlife Service (FWS) was contacted for information. However, because the information that FWS offers may be limited, a review of the Illinois natural heritage database should be requested to supplement the information already obtained. Also, a single survey performed on a single day is not sufficient to demonstrate the absence of bird species. Because bird counts are done annually in the vicinity of the facility, the Chicago Audubon Society should be contacted for additional information about sightings of threatened or endangered bird species at the facility and in areas adjacent to Lake Calumet. The assumption that threatened or endangered species will not use the facility or surrounding areas may be inaccurate given the high concentrations of birds that are known to pass through the Lake Calumet area.
- In item No. 4, you provided additional information about threatened or endangered species in the area of the CWMCS facility. However, the first paragraph of the response does not fully address U.S. EPA's comment concerning breeding bird populations. The phrase "or potentially occur" should be deleted from the first sentence because the black-crowned night heron, a state-listed endangered species, is known to nest in the area. In addition, the habits of nearby nesting bird populations should be researched to substantiate the claim that no bird

species spend a significant amount of time at or near the facility. Finally, the response addresses only wintering bird populations and does not identify additional species that nest in the area and that forage in Lake Calumet near the facility. The Chicago Audubon Society may be able to provide the missing information.

The response also discusses candidate endangered species known to occur within 5 miles of the facility. The response mentions that five avian species have been observed in the area, but it lists only three of them. The other two avian species should be identified, and the specific locations of all sightings should be researched so that the proximity of the avian species to the facility can be determined.

The following are U. S. EPA's comments to Attachment IV in your RESPONSE:

- **General Comment 2.** The evaluation of potential exposures of construction and utility workers was conducted primarily for the purposes of completeness. U.S. EPA does not condone any violations of OSHA rules and regulations. Sometimes, however, these rules and regulations are not fully followed, and exposures occur. The exposure scenario developed for construction and utility workers represents a conservative, upper-bound estimate of the potential exposures and risks for construction and utility workers even if appropriate rules and regulations are followed.
- **General Comment 3.** Section 5.0 of the SHHRA acknowledges that the calculation of upper-bound exposure point concentrations is one source of uncertainty that may contribute to the overestimation of risk. However, the procedure followed in developing exposure point concentrations adheres to the most recent U.S. EPA guidance. CWMCS's comment offers no alternative procedure for calculating exposure point concentrations other than to suggest that "analytical results obtained from the individual SWMUs may be indicative of conditions within the SWMU only." Even if the exposure frequency were reduced by a factor of up to 10 in order to reflect the smaller size of an individual SWMU as compared with the exposure areas designated in the SHHRA, the total estimated carcinogenic risk to construction workers would still be in the order of 1×10^{-5} and may still exceed 1×10^{-4} .
- **Specific Comment 1.** U.S. EPA acknowledges using background soil samples different from those used by CWMCS in the baseline RA report. Although the source of the fill material upon which the facility and adjacent piers were constructed is not known, U.S. EPA believes that the fill material best represents site-specific background conditions. A comparison of background fill locations with on-site and potentially contaminated fill locations would best establish the nature and extent of site-related contamination.
- **Specific Comment 5.** The SHHRA specifically refers to Figure 2-7 of the RFI report and Table 2 of the SHHRA to describe the exposure areas. Because the potential exposures evaluated in the SHHRA all involve

exposure to contamination below grade during construction or utility work, the presence or absence of asphalt at the exposure areas is not significant.

U.S. EPA acknowledges that the SHHRA evaluated only a portion of the available sediment samples. The sediment samples selected were from locations considered to be those most accessible to subsistence fisherman. U.S. EPA considers the sediment samples collected immediately north of the biobeds and the vault to represent RME conditions.

● **Specific Comment 6. Area A:** Upon review, U.S. EPA acknowledges that samples FG-8, FG-10, and G-123S should have been considered for Area A. However, considering these samples for Area A would only minimally affect the results of the SHHRA. In addition, sample FG-3 was collected immediately south of the approximate southern boundary of Area A; samples B-331, G-332, and B-333 were collected immediately north of this boundary. Therefore, sample FG-3 was correctly considered for Area B.

U.S. EPA agrees that no analytical data are available for sampling location D-2 and that it should not be listed among the sampling locations for which analytical data are available. However, elimination of sample D-2 from Table 2 will not affect the results of the SHHRA.

Area B: Sample FG-3 was correctly considered for Area B, but samples FG-8 and FG-10 should have been considered for Area A.

Area C: Upon review, U.S. EPA acknowledges that samples B-304, FG-16, G-120S, and G-121S should have been considered for Area C. Because of the cap in the vault area, it was assumed that there would be significant exposure associated with sampling location SS-22; therefore, this location was not considered for Area C. Figure 2-7, which was used to locate the sampling locations, does not show sampling location SS-10. Because this sampling location could not be confirmed, it was not considered for any of the exposure areas.

U.S. EPA acknowledges that inclusion of the sampling locations discussed above would affect the exposure point concentrations and would affect the selection of contaminants of potential concern. However, the extent of these effects is not expected to be significant and is unlikely to impact the overall results of the SHHRA.

Furthermore, upon review of the data included in the SHHRA, it was determined that subsurface samples marked with the suffixes "F2" and "D" were in fact included in the data set. However, it is possible that excavations as deep as 20 feet below ground surface (bgs) could result from construction activities (such as placement

of footings or construction of basements). Therefore, it is reasonable to consider analytical results for soil samples collected up to 20 feet bgs during development of exposure point concentrations.

Similarly, as indicated in Table 1 of Attachment IV, the sampling depths of the groundwater samples from locations G-302, G-318, G-324, G-336, G-342, FG1-GW through FG8-GW, and FG10-GW through FG12-GW are all less than 13 feet bgs. U.S. EPA believes that groundwater at these depths would likely seep into an excavation reaching a depth of 10 to 20 feet bgs; therefore, consideration of analytical results for samples from these depths is appropriate.

- **Specific Comment 7.** In the cases where analytical results were presented as "ND" and "BMDL," the sample quantitation limit (SQL) was calculated by multiplying the sample-specific dilution factor (DF) by the reported quantitation limit (QL). If DFs were not provided, the samples were assumed to not have been diluted (DF = 1). If sample-specific QLs were not provided, the QLs for samples from the same media were adopted. Each "ND" and "BMDL" value was replaced with a value equal to one-half of the calculated sample-specific SQL.

- **Specific Comment 8.** As reported in Section 3.2.2, page 9 of the SHHRA, the analysis of the data's distribution and the statistical comparison to background concentrations for inorganics were performed before the substitute values (equal to one-half of the sample-specific SQLs) were added to the data set.

ATTACHMENT II

COMPARISON OF SEDIMENT CONTAMINANTS TO SCREENING BENCHMARKS

Contaminant	Dry Weight			Organic Carbon Normalized	
	S-1 µg/g	LEL ¹ µg/g	ER-M ² µg/g	S-1 µg/g _{oc}	SQC µg/g _{oc}
Benzo(a)pyrene	4.74	0.370	2.50	158	
Benzo(b)fluoranthene	9.29				
Benzo(k)fluoranthene	3.60	0.240		309	
Chrysene	7.16	0.340	2.80	120	
Phenanthrene	10.1	0.560	1.38	336	180 ³
Pyrene	12.4	0.490	2.20	413	
Fluoranthene	16.1	0.750	3.60	536	620 ⁴
PAH (total)	63.4	4	35		

¹ Persaud, D., R. Jaagumagi, and A. Hayton. August 1993. *Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario*. ISBN 0-7729-9248-7. Ontario Ministry of the Environment.

² Long, E. R. and L. G. Morgan. 1991. "Potential for Biological Status Effects of Sediment-sorbed Contaminants Tested in the National Status and Trends Program." *NOAA Technical Memorandum NOS OMA 52*. National Oceanic and Atmospheric Administration. Second Printing, August 1991. Seattle, Washington.

³ USEPA. September 1993. *Sediment Quality Criteria for the Protection of Benthic Organisms: Phenanthrene*. EPA-822-R-93-014. Office of Science and Technology, Health and Ecological Criteria Division, Washington, D.C.

⁴ USEPA. September 1993. *Sediment Quality Criteria for the Protection of Benthic Organisms: Fluoranthene*. EPA-822-R-93-012. Office of Science and Technology, Health and Ecological Criteria Division, Washington, D.C.

**CWM CHEMICAL SERVICES, INC.
CHICAGO INCINERATOR FACILITY
FINAL RCRA FACILITY INVESTIGATION REPORT
February 1995**

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ERRATA

The following corrections have been made to this document since the original November 1993 submittal.

1. Section 4.2.5.1, Page 4-64. The textual reference to Figure 4-2 has been changed to Figure 4-1.
2. Section 4.2.5.1: Figure 4-2 was renamed to Figure 4-1 "Simulated Groudwater Flux into Lake Calumet" and the following additons were made to this figure:
 - a. A 1-foot wide section of the aquifer, oriented north-south (left and right respectively) is appropriately indicated in Figure 4-1.
 - b. The groundwater discharge and water table surface are represented on Figure 4-1.
 - c. The fluxes shown on the north side of the pier (left as one views Figure 4-1) have been corrected to match those presented in Table 4-7.
3. Section 4.2.5.1, Page 4-66. The text has been corrected to indicate "...a no-flow condition on all four sides and at the base." and "...the north and south model boundaries (left and right respectively), ..."
4. Section 4.2.5.2, Page 4-67. The text has been corrected to match Table 4-7 and therefore indicates "... a groundwater flow of approximately 0.6 cubic feet per day per linear foot of pier has been modeled."
5. Appendix M has been renamed "MODFLOW Data" and includes the model output.

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PART ONE
FACILITY INVESTIGATION
FEBRUARY 1995**

Dames & Moore No. 13963-055

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1.0 INTRODUCTION

1.1 Purpose

The purpose of this final RCRA Facility Investigation (RFI) Report is to present the results of two phases of investigation at the CWM Chemical Services, Inc. (CWMCS) Chicago Incinerator, in compliance with RCRA Corrective Action Plan ILD 000 672 121. The Corrective Action Plan outlined seven tasks for completion of the RCRA Facility Investigation. These included: (I) Description of Current Conditions; (II) RFI Workplan Requirements; (III) Facility Investigation; (IV) Evaluation of Corrective Measures Technologies; (V) Investigation Analysis; (VI) Laboratory and Bench-Scale Studies, and (VII) Reports. The negotiated scope of work for Phase I (Work Plan) of this investigation was approved by the United States Environmental Protection Agency (USEPA) in August, 1989; the negotiated scope of work for Phase II (Work Plan Addendum) was approved by USEPA in August, 1991. This completed the requirements for Tasks I and II. A Draft RFI Report was submitted in June, 1992, in partial completion of Tasks III and V as described under Task VII. The data developed from these investigations and the results presented in this draft report were intended to support a Corrective Measures Study as described under Task IV and, if necessary, Laboratory and Bench-Scale Studies under Task VI. Agency review comments received on the Draft RFI Report were received by CWM on October 14, 1992. A response to these comments was submitted to the Agency on January 6, 1993. Additionally, issues presented in the Report were addressed at a meeting held between CWM and the Agency on May 5, 1993.

Agency review comments received in correspondence and discussed at the May 5, 1993 meeting have been incorporated into this Final RFI Report. Additionally, an evaluation of Corrective Measures Technologies (Task IV of the RCRA Corrective Action Plan) has been included as Part Two of this report.

The three parts of this Final RFI are as follows:

- | | |
|--------|---|
| Part 1 | Facility Investigation |
| Part 2 | Evaluation of Corrective Measure Technologies |
| Part 3 | Investigation Analysis |

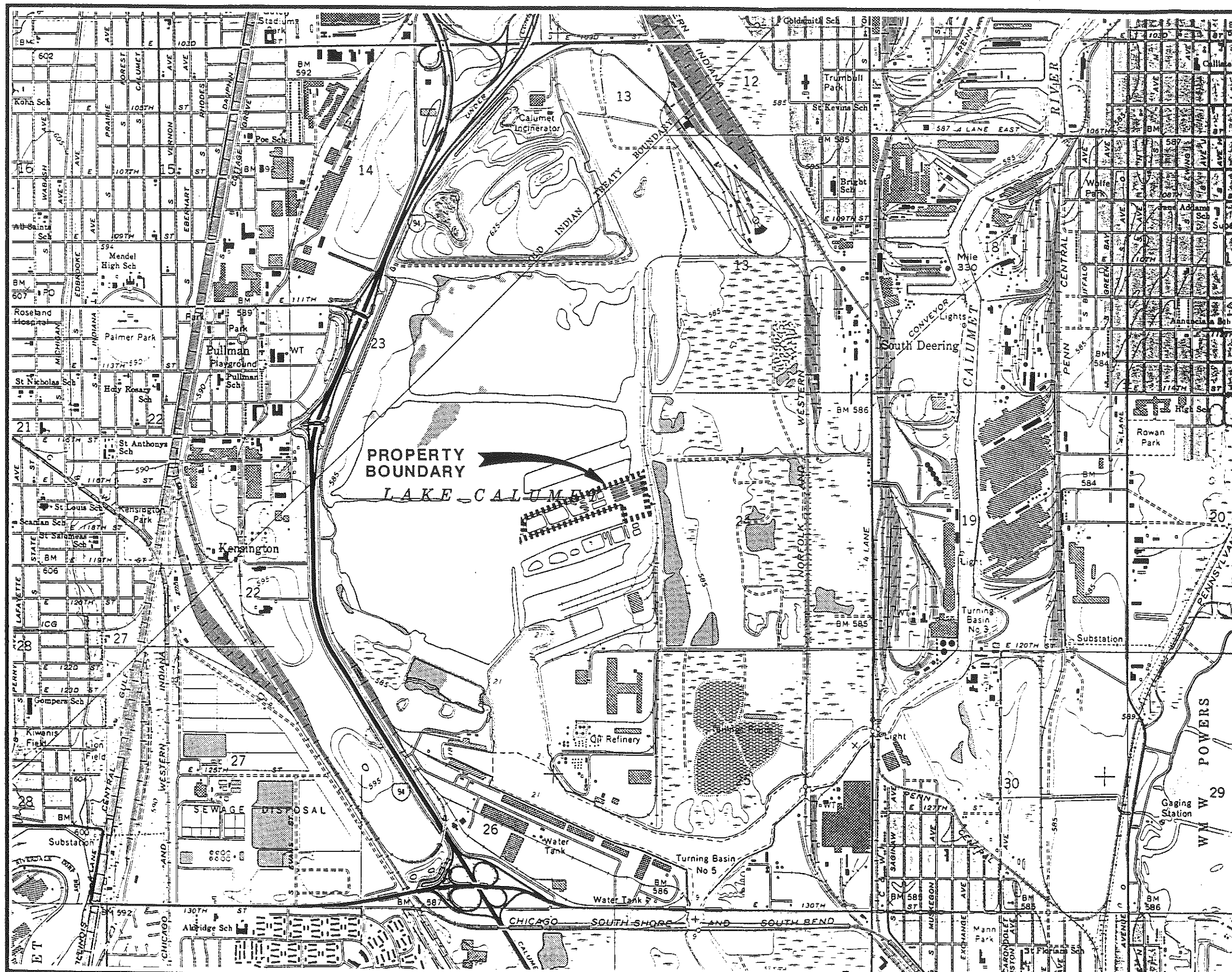
Data validation has been included in Part 3. Ecological and human health risk assessments are also included in Part 3.

1.2 Location

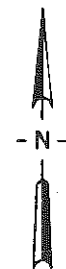
CWM Chemical Services, Inc. (CWMCS) operates a hazardous waste incinerator at 11700 South Stony Island Avenue, Cook County, Chicago, Illinois. The incinerator property is located on the east shore of Lake Calumet and occupies about 30 acres of land constructed on fill and comprises a pier area and an active incineration area. The property is leased from the Illinois International Port. The exact location is Section 24, Township 37 North, Range 14 East, between 41 41' 11" and 41 41' 23" west longitude, and 87 34' 33" and 87 35' 8" north latitude. A regional location map for the facility is shown on Figure 1-1.

1.3 Project Background

The RCRA Corrective Action Plan for the facility was developed as part of a Consent Judgement between Chemical Waste Management (CWM) and the USEPA in response to a RCRA Facility Assessment (RFA) performed by the Illinois Environmental Protection Agency (IEPA) in 1987. The RFA identified nine former solid waste management units (SWMUs) that were active at the facility in the 1970's, during the tenure of Hyon Waste Management, Inc. (Hyon), the original facility operator. One additional potential source area not identified in the Corrective Action



BASE MAP SOURCE:
USGS 7.5 MINUTE TOPOGRAPHIC
QUADRANGLE, LAKE CALUMET,
ILLINOIS-INDIANA, DATED 1965,
PHOTOREVISED 1973,
PHOTOINSPECTED 1977.



FEB. 23 1995

SCALE: 1"=2000'

CWM CHEMICAL SERVICES, INC.
CHICAGO INCINERATOR

FIGURE 1-1
REGIONAL LOCATION MAP

DRN-BY SLH	PROJECT 13963-055
DATE NOV. 1993	DAMES & MOORE

Plan, but later identified during the RFI Work Plan preparation, was the former Hyon Tank Farm located within the present active incineration area. The SWMUs identified in the Work Plan include the following:

Pier Units

1. Biochemical Filter Beds (biobeds) (SWMU #1)
2. Activated Sludge Basins (SWMU #2)
3. Drum Handling Area (SWMU #3)
4. High Solids Area (SWMU #4)
5. Wastewater Basin #1 (SWMU #5)
6. Wastewater Basin #2 (SWMU #6)
7. Process Water Underground Pipe System (SWMU #9)

Incineration Active Area Units

1. Chemical Treatment Area (SWMU #7)
2. Biochemical Treatment Area (SWMU #8)
3. Tank Farm (not identified by IEPA)

Details on these SWMUs are discussed in Section 3.0 of this report.

The Hyon Envirotherm (Envirotherm operated at the property for a short time in 1980) facility permit was transferred to SCA Chemical Services, Inc. (SCA) in November, 1980. In 1981, SCA implemented a pier restoration program which consisted of construction of a clay-lined vault in the area of Wastewater Basin #1, excavation and solidification of residue from the other basins and placement in the vault, and backfilling of the excavated basins with innocuous fill. Subsequently, the underground pipe network, excluding the process water underground pipe system, was abandoned in place (plugged with concrete), and the active incineration units were dismantled and replaced with other operating appurtenances.

CWMCS acquired the assets of SCA in 1985, and continued to operate the incinerator under RCRA Interim Status until February, 1991. At that time, a facility accident resulted in suspension of commercial operations. Operations at the facility have been discontinued until such time that a RCRA Part B permit is issued.

The approved RFI Work Plan and RFI Work Plan Addendum have been carried out independent of the incinerator permit negotiations. These plans detailed a surface water, sediment and subsurface investigation of the facility with respect to the former SWMUs. A plan view of the site showing current facilities along with Phase I and Phase II sampling points is shown on Figure 1-2 (two drawings). This report presents the results and recommendations of these investigations.

2.0 ENVIRONMENTAL SETTING

2.1 Surface Conditions

As described previously, SCA Chemical Services, prior to acquisition by Chemical Waste Management, conducted a pier restoration project in 1981 and 1982 which eliminated many of the SWMUs on the pier as active waste handling units. This work was done pursuant to a Compliance Agreement between IEPA and the Chicago Regional Port District (now the Illinois International Port). Wastewater Basins #1 and #2 (SWMU's #5 and #6) were drained and discharged to a Metropolitan Sanitary District of Greater Chicago (MSDGC) sewer. An engineered clay-lined vault was constructed at the location of Wastewater Basin #1 (SWMU #5). Sludges from the other basins were excavated and placed in the vault. The vault was then capped with compacted clay. Wastewater Basin #2 (SWMU #6), the High Solids Basin (SWMU #4), and the biobeds (SWMU #1) were then backfilled and graded to their present level.

During the fall of 1987, the remnants of the Activated Sludge System (SWMU #2) were excavated and transported off-site for disposal. This was performed to prepare the area for the above-ground storage tanks constructed to replace the interim status surface impoundments.

The Underground Pipe Network (SWMU #9) was partially removed and plugged near the northeast process water impoundment, but remains in place in other locations. The Drum Handling Area (SWMU #3), is occupied by a fire water storage tank. The remaining waste management units identified are in the active incineration area. The Chemical Treatment Area (SWMU #7), the Biochemical Treatment Area (SWMU #8) and the Hyon Tank Farm have either been replaced with other operational facilities or have been paved.

Other details on the SWMUs are discussed in Section 3.0.

The results of these construction efforts at the facility have resulted in an essentially flat surface with operating facilities confined to the active incineration area and process water storage tank and pretreatment system area, located east of the former Stabilization Basin Lagoons (Interim Status Surface Impoundments). The remainder of the site is generally barren. A parking lot covers most of the east biobed area. Undeveloped land is located between the parking lot and the above ground process water storage tanks. West of the closed impoundments, the land surface is covered with volunteer vegetation. The vault is visible as it creates a mound that crests about 10 feet above the surface of the adjacent land.

2.2 Hydrogeology

2.2.1 Regional and Facility Characteristics

Regional Stratigraphy

The oldest rocks in the Chicago region are the Precambrian crystalline igneous-metamorphic basement rocks of the craton (the stable rocks of the continental land mass). These rocks of the stable interior of the North American continent are found only deep within the subsurface. It is estimated that the Precambrian surface ranges from a depth of 2,500 to 3,000 feet along the north boundary of the Chicago area, and from a depth of 5,000 to 5,500 feet along the southern boundary. The surface is at a depth of approximately 4,500 feet in the Chicago Loop (14).

Layered Paleozoic sedimentary rocks lie unconformably over the craton. The rock types include limestone, dolomite, shale, siltstone, mudstone, and sandstone. The sequence of strata is largely continuous representing transgressive or regressive cycles of epeiric seas (extensive shallow seas that inundated the continent) during Paleozoic time. Between each sequence were episodes of erosion creating unconformities. L. L. Sloss designated six major unconformity bounded sequences for the North American continent (15). The Cambrian-Ordovician Sauk sequence and the Ordovician-Silurian Tippecanoe sequence represent the bulk of the sedimentary rocks that

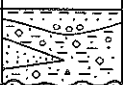



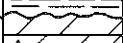
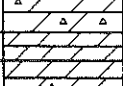
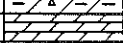
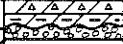
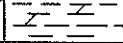
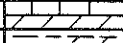
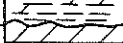


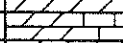
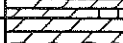

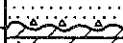
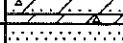
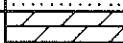

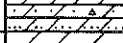
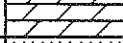
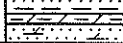
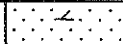
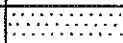
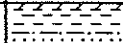
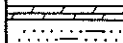

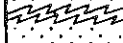


comprise the bedrock of the Chicago area. Subsequent sequences were deposited at later times, but have since been eroded. A stratigraphic column showing the bedrock geology for the Chicago area is shown in Figure 2-1.

The Pleistocene history of the Chicago area is marked by continental glaciation. The advancing glaciers truncated the bedrock surface at approximately its present day elevation. Four major glacial stages are marked by separate occurrences of glacial advance and retreat. The most recent is known as the Wisconsin Stage. The Lake Michigan Lobe of the continental ice sheet traversed the present area of Lake Michigan into the Chicago area. End moraines now mark the extent of each advancement of the Lake Michigan Lobe. These moraines follow the outline of Lake Michigan and can be traced from Wisconsin to Indiana. A blanket of glacial deposits composed of existing glacial material and bedrock were eroded and re-deposited during glacial times. This material includes glacial moraines, glaciofluvial (river), and glaciolacustrine (lake) deposits.

During Pleistocene times, an expanded portion of glacial Lake Michigan covered much of what is present day Cook County. This portion of the lake is called Lake Chicago. The effect of this lake was to cause the eastern portion of Cook County to be essentially flat with little relief.

Lake Chicago was given a separate name from Lake Michigan since it drained southwest through the Sag and Des Plaines Valleys and not into Lake Michigan as lake levels declined. The area once occupied by Lake Chicago is now known as the Chicago Lake Plain.

Scattered lacustrine deposits are found in the former lake bed. The lacustrine deposits have been mapped as three separate units. Figure 2-2 is a diagram of the surficial geology of the area (16). The Carmi and Dolton Members of the Equality Formation make up the first two units. The third unit is mapped as a separate member consisting of Lake plain deposits. The Equality

Time Stratig.				Rock Stratigraphy		GRAPHIC COLUMN	Thickness (Feet)	KINDS OF ROCK		
SYSTEM	SERIES	STAGE	MEGA-GROUP	GROUP	FORMATION					
QUAT.	DES. PLEIS.				(See fig. 15)		0-350	Till, sand, gravel, silt, clay, peat, marl, loess		
PENN.	DES. PLEIS.			Kewanee	Carbondale		0-125	Shale, sandstone, thin limestone, coal		
					Spoon		50-75	As above, but below No. 2 Coal		
MISS.	VAL.				Burl-Keokuk		0-700	Limestone	Only in Des Plaines Disturbance	
	KIND.				Hannibal			Shale, siltstone		
DEV.	UP.				Grassy Creek		0-5	Shale in solution cavities in Silurian		
SILURIAN	ALEX. NIAGARAN		Hunton		Racine		0-300	Dolomite, pure in reefs; mostly silty, argillaceous, cherty between reefs		
					Waukesha		0-30	Dolomite, even bedded, slightly silty		
					Joliet		40-60	Dolomite, shaly and red at base; white, silty, cherty above; pure at top		
					Kankakee		20-45	Dolomite; thin beds; green shale partings		
					Edgewood		0-100	Dolomite, cherty, shaly at base where thick		
	CIN. RICH.			Maquoketa	Nedo		0-15	Oolite and shale, red		
					Brainard		0-100	Shale, dolomitic, greenish gray		
					Fl. Atkinson		5-50	Dolomite, green shale, coarse limestone		
					Scales		90-120	Shale, dolomitic, gray, brown, black		
					Wise Lake		170-210	Dolomite, buff, pure		
ORDOVICIAN	CHAMPLAINIAN	TRENT.	Ottawa	Galena	Dunleith			Dolomite, pure to slightly shaly; locally limestone		
					Guttenberg		0-15	Dolomite, red specks and shale partings		
					Nachusa		0-50	Dolomite and limestone, pure, massive		
				Platteville	Grand Detour		20-40	Dolomite and limestone; medium beds		
					Mifflin		20-50	Dolomite and limestone, shaly, thin beds		
					Pecatonica		20-50	Dolomite, pure, thick beds		
	CANADIAN		Knox	Ancell	Glenwood		0-80	Sandstone and dolomite, silty; green shale		
					St. Peter		100-600	Sandstone, medium and fine grained; well rounded grains; chert rubble at base		
					Shakopee		0-70	Dolomite, sandy; oolitic chert; algal mounds		
					New Richmond		0-35	Sandstone, fine to coarse		
					Oneota		190-250	Dolomite, pure, coarse grained; oolitic chert		
CAMBRIAN	CROIXAN	FRAN.			Gunter		0-15	Sandstone, dolomitic		
					Eminence		50-150	Dolomite, sandy		
					Potosi		90-220	Dolomite; drusy quartz in vugs		
					Franconia		50-200	Sandstone, glauconitic; dolomite, shale		
					Ironton		80-130	Sandstone, partly dolomitic, medium grained		
	DRESBACHIAN				Galesville		10-100	Sandstone, fine grained		
					Eau Claire		370-570	Siltstone, dolomite, sandstone and shale, glauconitic		
					Mt. Simon		1200-2900	Sandstone, fine to coarse; quartz pebbles in some beds		
PRE-CAM.								Granite		

SOURCE: SUMMARY OF THE GEOLOGY OF THE CHICAGO AREA; CIRCULAR 460 1971, ILLINOIS STATE GEOLOGICAL SURVEY, URBANA, ILLINOIS 61801

**CWM CHEMICAL SERVICES INC.
CHICAGO INCINERATOR**

**FIGURE 2-1
Geology of Chicago Area**

DRN. BY: MG

PROJ. NO.: 13963-052-29

DATE: JUNE 1992

DAMES & MOORE

Formation represents recent Lake Chicago deposits. The Lake plain deposits represent early Lake Chicago lacustrine deposits on top of glacial till.

The Carmi Member consists of quiet water, near shore lake sediments. It is a well bedded locally laminated unit containing thin beds of clay. Lenses of sand and gravel occur along beaches. The Dolton Member consists of shallow water near shore lake sediments, deposited by beaches, bars, spits, and deltas. It is predominantly a medium-grained sand containing beds of silt where it is gradational to the Carmi Member. The Carmi Member is absent where the Dolton Member is present. The Equality Formation was deposited on older Lake plain deposits. The older Lake plain deposits represent floors of glacial lakes deposited on the till sheet. Low lying areas on the till were filled in while higher elevations on the till were flattened by wave erosion.

The Wedron Formation is the Glacial till that underlies the lacustrine deposits as well as most of Cook County. The Wedron Foundation is made up of the Wadsworth and Yorkville Till and Lemont Drift Members. Glacial till is equivalent to Wedron Formation in this report since the members are quite similar. Extensive urbanization removed some of these surficial geologic features, and manmade fills have covered others.

Facility Stratigraphy

The CWMCS Chicago Incinerator Facility is built on a pier constructed of man made fill extending into Lake Calumet. Lake Calumet along with nearby Wolf Lake are remnants of Lake Chicago.

Site stratigraphy is typical of that found in the Chicago Lake plain. Site specific stratigraphic information was collected from borings advanced during both the Phase I (October 1989) and Phase II (October 1991) portions of the RFI. Phase I boring logs are included in Appendix A. Phase II boring logs are included in Appendix B. Phase I borings were advanced a maximum

of 10 feet beneath the fill material. During the Phase II investigation seven borings were advanced to bedrock, encountered at depths ranging from 75 to 80 feet. Documentation on the surficial bedrock unit was obtained by advancing a core barrel 10 feet into the bedrock. Approximately 15 to 20 feet of man made fill and 60 to 65 feet of unconsolidated glacial deposits overly the bedrock surface.

The uppermost bedrock unit beneath the facility is called the Racine Formation. This formation is the uppermost member of the local Silurian system. The Silurian system is composed of dolomite members and formations of the Niagaran and Alexandrian series. Boring logs for deep wells within a one mile radius show approximately 400 to 450 feet of Silurian dolomite overlying the Ordovician aged Maquoketa Shale. These boring logs have been included in Appendix C (6).

Regionally, the Racine Formation thickens to the east along a gentle eastward dip of the strata. To the west, the Racine Formation thins as an erosional surface. The Racine Formation is characterized by large lateral interbedded reefs. The reef structures are pure dolomite containing little argillaceous material. Surrounding the reefs are beds of silty and argillaceous dolomite. Such interbedded reefs lie beneath the CWMCS facility. The nearest reef is the Stony Island reef structure 3 miles north of the facility.

Recovered bedrock core samples were logged by Dames & Moore. Detailed descriptions of the core can be found on the boring logs in Appendix B. The Racine formation is a greenish-gray argillaceous fine grained massive dolomite. Recovered cores consist of fresh rock with slight to moderate weathering near the bedrock surface. Mechanical breaks in the recovered core were frequent. Core recovery varied from 62.3% to 96.3% averaging 74.4%. RQD (Rock Quality Designation) values ranged 39.2% to 91.8% averaging 62.4%. RQD is the sum of recovered core lengths greater than 4" divided by the sum of all recovered core lengths. RQD is used to qualify mechanical properties of rock. Based on the RQD value rock quality is classified as

follows: very poor 0-25%; poor 25-50%; fair 50-75%; good 75-90%; and excellent 90-100% (19).

The overlying unconsolidated deposits identified for this investigation can be divided into four distinctive units. These units are shown on geologic cross-section A-A¹ and B-B¹ on Figure 2.3. Dames & Moore contacted Ms. Ardith Hansel of the Illinois State Geological Survey, Quaternary Framework Studies Section. Ms. Hansel reviewed Section 2.0, Environmental Setting of the Draft RFI Report. Her comments have been incorporated into this Final RFI Report.

The uppermost unit consists of construction debris used to construct the active area of the facility and the pier built into Lake Calumet. This unit is referred to as Fill on Figure 2-3. It is 13 to 20 feet thick, typically 15 feet, and thickens to the west as the pier extends into Lake Calumet.

Beneath the fill material is a unit referred to as the Upper Lacustrine unit. Regionally, this unit corresponds to the Wadsworth Till member of the Wedron Formation. The Wadsworth Till member is similar in appearance to lacustrine deposits, and is particularly lacustrine in places. This unit consists of a uniform, light gray, silty clay that is continuous across the facility. It ranges in thickness from 8 to 17 feet, typically 10 feet thick. Thickness gradually increases to the west along the long axis of the pier, extending into Lake Calumet.

Beneath the Upper Lacustrine unit lies the Lower Lacustrine unit. This unit corresponds regionally to the Proglacial Wadsworth Till. This is an ice contact deposit. Overall, the unit is heterogeneous with layers. Layers within the unit consist of clay, silty clay, clayey silt, silt, and small sand seams. The unit ranges in thickness from 5 to 15 feet. Sand seams encountered during the investigation ranged in thickness from 3 to 24 inches. This unit was deposited by running water sorting material and creating the layers. Consequently, layers are horizontal and discontinuous.

Beneath the Upper Lacustrine and Lower Lacustrine units lies a Glacial Till unit. Regionally this corresponds to the Lemont Drift member of the Wedron formation. The till is characterized by fine gravel and sand in a dense silty clay or clayey silt matrix. With the exception of angular, coarse, gravel-size clasts of bedrock found immediately above the bedrock, coarse grained material is rare. The thickness varies from 35 to 40 feet. Few clayey or silty sand seams were encountered during the investigation. These are bounded above and below by the till.

Regional and Facility Hydrogeology

Groundwater resources in the Chicago area are divided into four aquifer systems as follows: (1) aquifers composed of shallow sand and gravel deposits in the glacial material; (2) the shallow dolomite aquifer; (3) the Cambrian-Ordovician aquifer; and (4) The Mt. Simon aquifer, including the basal sandstone member of the Eau Claire Formation.

Shallow sand and gravel aquifers and the shallow dolomite aquifer are hydraulically connected, obtaining recharge from local precipitation. Sand and gravel aquifers are present in bedrock valleys containing predominantly alluvial or outwash deposits. The shallow dolomite aquifers are composed of the uppermost Silurian bedrock formations. These formations lie stratigraphically above the Maquoketa Shale Group which separates it from the underlying Cambro-Ordovician aquifer. Groundwater from this aquifer system is obtained primarily from the Iron-ton-Galesville and Glenwood-St. Peters Sandstones. Recharge for the Cambro-Ordovician system occurs along the western edge of the Chicago area where the Maquoketa Shale is absent. The Cambro-Ordovician aquifer is separated from the Mt. Simon aquifer system by overlying shale and siltstone beds of the Eau Claire Formation. The recharge area of the Mt. Simon aquifer system is in an outcrop area in the south central portion of Wisconsin.

Site specific hydrogeologic units are discussed in more detail in Section 2.2. The four most important factors concerning site specific hydrogeology are: (1) The uppermost water bearing unit at the facility is composed of the saturated portion of the fill material; (2) Lake Calumet is in direct hydraulic connection with the uppermost water bearing unit; (3) The fine grained low permeability glacial deposits beneath the fill restrict the downward flow of groundwater creating a perched aquifer condition; and, (4) The glacial material behaves as an aquitard and a confining layer for the dolomite aquifer.

2.2.1.1 Regional Structural Geology

Regional structural geology of the Chicago area is composed of the broad, gently sloping Kankakee Arch. The Kankakee Arch connects with the Wisconsin and Cincinnati Arches separating the Illinois Basin to the southwest, and the Michigan Basin to the northeast. The Kankakee Arch is composed of a thick sequence of Paleozoic sedimentary rocks. The beds dip slightly to the east due to the eastward plunge of the arch.

The Paleozoic sequence of sedimentary rocks thickens away from the Kankakee Arch, moving northeast into the Michigan Basin and southwest into the Illinois Basin. Overall, the rocks were deposited as horizontal layers. Tectonic forces during Paleozoic time were responsible for warping the continent, creating basins and arches. No active faults are known to exist in the Chicago area; however ancient structural disturbances such as the Sandwich Fault Zone, and the Des Plaines Disturbance are well documented. The Des Plaines Disturbance is located in northern Cook County. The Sandwich Fault Zone is located near Joliet, Illinois.

2.2.1.2 Depositional History

Glacial tills of the Wedron Formation were deposited during the latest glacial advance during the Wisconsin stage. The till is composed of pulverized bedrock and soil material. During the Wisconsin stage, glacial ice moved as lobes rather than as a single continental ice sheet. The flow of ice lobes was governed by topography. In the Chicago area, the Lake Michigan lobe

traversed south in the basin now occupied by Lake Michigan. End moraines mark the extent of each glacial advance within the Wisconsin stage. These end moraines can be traced from Wisconsin to Indiana around the periphery of Lake Michigan. Sheets of glacial till were deposited by the glaciers, younger tills on top of older tills.

Approximately 13,500 y.b.p. (years before present) glacial Lake Chicago formed between present day Lake Michigan to the east and the Tinley Moraine to the west. As discussed previously, Lake Chicago was part of glacial Lake Michigan in the Chicago area. It was given a separate name since it drained west via the Des Plaines-Sag Channels and not east into Lake Michigan.

Proglacial lakes (lakes formed at the edges of continental ice sheets) are common in the proglacial environment. Lakes are particularly common in situations where regional slope is toward the ice margin, and drainage is ponded, or where drainage is ponded by earlier formed end moraines beyond the active ice margin. This was the situation under which glacial Lake Chicago formed.

Lake plain deposits of sand, silt, and clay were deposited in depressions on top of eroded till sheets. Till sheets were eroded by wave action in the shallow lake. Former shorelines record at least three lake levels as Lake Chicago drained. The lakebed slopes gently to the east toward Lake Michigan. As the lake drained, the shoreline moved toward Lake Michigan.

The Illinois State Geological Survey map (Figure 2-2) shows the surficial deposits deposited in the Chicago Lake plain. Quiet water lake deposits are the most recent deposits formed during the lower lake levels. Bars, spits and lake deltas also formed. The quiet water deposits are mapped as the Carmi member of the Equality Formation. The bars, spits, and lake deltas are mapped as the Dolton member of the Equality Formation. The members grade laterally into one another, but are not superimposed (14). Older lacustrine deposits are mapped as lake plain

deposits. They lie beneath the Equality Formation and are present at the ground surface west of Lake Calumet. Glacial tills of the Wedron Formation lie beneath the lacustrine deposits over the entire area.

Wolf Lake and Lake Calumet are remnants of former Lake Chicago. Wetlands are prominent in the low lying poorly drained lakebed. As a result, peat deposits can be found on top of lacustrine deposits. Urbanization in the past 100 years has resulted in filling in large portions of the Lake plain.

2.2.1.3 Areas of Recharge and Discharge

In the Chicago area, aquifers of glacial and alluvial deposits recharge directly from local precipitation. Regionally the shallow Silurian dolomite aquifer also recharges from local precipitation. The Cambro-Ordovician aquifer is recharged west of the outcrop area of the Maquoketa Shale. This area is located at higher elevations along the western edge of Chicago. The deeper Mt. Simon aquifer is recharged where it outcrops in the south central portion of Wisconsin.

The area covered by Cook County, in particular the Chicago Lake plain, provides relatively small amounts of recharge to the shallow aquifer system, which includes glacial drift aquifers and the Silurian dolomite (7). The Chicago Lake Plain is a regional discharge area. Artificial drainage further limits the amount of recharge to the shallow aquifers.

Precipitation in the active paved area of the CWMCS facility is collected, treated and discharged into the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) Sewer. The majority of the precipitation onto the unpaved areas of the facility is lost to evapotranspiration and overland flow. Minor amounts of precipitation infiltrate into the fill. The low permeability of the underlying glacial deposits restricts the downward movement of flow. Consequently, groundwater flowing through the fill material discharges primarily into Lake Calumet.

2.2.1.4 Regional and Facility Specific Groundwater Flow Patterns

Regional flow in the bedrock aquifers in Cook County is eastward toward Lake Michigan. The potentiometric surface of the deep Cambro-Ordovician aquifer has been steadily decreasing. Early in the history of Chicago, the potentiometric surface was 80 to 100 feet higher than Lake Michigan. Currently, the potentiometric surface ranges between 300 to 600 feet below Lake Michigan as a result of historic and current groundwater use.

In the Chicago area, regional flow in the unconsolidated deposits is also toward Lake Michigan. However, since the Chicago Lake plain is a regional discharge area, localized flow conditions may not indicate this. Groundwater flow conditions at the CWMCS facility are dominated by Lake Calumet. At the adjacent Paxton Landfill, east of the facility, groundwater flow is radial away from the landfill (18). East of the landfill, groundwater flow is east towards Lake Michigan. West of the landfill, groundwater flow is west towards Lake Calumet and the CWMCS facility.

The results of the Phase I investigation indicate that localized flow is west along the axis of the pier through the saturated portion of the fill material. The elevation of groundwater in wells near the edge of the pier is just above lake level. The elevation of groundwater in the fill is approximately 7 feet above Lake Calumet on the eastern property boundary. Higher groundwater elevations on the pier are interpreted to be groundwater mounds resulting from low permeability material in the fill restricting flow. Such groundwater mounds are present in the former biobeds area (SWMU #1), the former wastewater basin #2 (SWMU #6), and along the berm of the High Solids Basin (SWMU #4) (See Figure 3-1).

2.2.1.5 Seasonal Variations in the Flow Regime

Minor fluctuations have been observed in the water levels in wells (RFI wells) on the CWMCS property, but the flow directions remain the same. All of the wells are screened in the saturated portion of the fill material above the lower lacustrine layer. These fluctuations can be attributed

to seasonal changes. Water levels are generally higher in the spring when infiltration from the spring melt is greatest. The seasonal low is usually seen at the end of summer, and water levels rise again in late fall completing the annual cycle. Several monitoring wells at the Paxton Landfill are screened in glacial deposits, as well as fill material placed above the lower lacustrine layer. These monitoring wells illustrate the same phenomena (8). Since the saturated portion of the fill material is in hydraulic connection with Lake Calumet, seasonal variations of Lake Calumet are also reflected in the RFI wells.

Seasonal variations of the deep bedrock aquifer were not studied. The facility area is a regional discharge area and infiltration to the underlying bedrock is expected to be quite low. Variations in the flow regime would most likely be the result of groundwater pumping rather than seasonal effects.

2.2.2 Regional and Facility Topographic Features

Three principal types of terrain are recognized in Cook County (17). They are uplands, plains, and lowlands. Classification of each terrain has been made on the basis of relative elevation, slope characterization, and sequence and character of the subsurface material. The uplands terrain is present in the extreme northwestern portion of Cook County. The lowlands occupy the Chicago Lake plain which is located in the eastern portion of Cook County. The terrain between the uplands and lowlands are plains.

The soils of the Chicago Lake plain are naturally poorly drained. Fine grained soils restrict infiltration, and paved areas increase runoff. Most of the area is served by storm sewers, but a major runoff event will cause flooding. The active area and pier on which the CWMCS Incinerator Facility is located has little relief. The highest elevation, at the top of the vault, has an elevation of 20 feet above City Datum. The remainder of the facility has an elevation between 10 and 15 feet above City Datum. The perimeter of the pier slopes towards Lake Calumet having an elevation approximately equal to City Datum. City Datum for the City of

Chicago is the mean elevation of Lake Michigan (579.88 feet MSL). Precipitation falling in the paved active area is collected, treated and discharged to the Metropolitan Water Reclamation District of Greater Chicago. Minor amounts of precipitation from the unpaved areas infiltrate into the fill, but the majority flows into Lake Calumet as overland flow. No streams or drainage ways are located on the CWMCS property.

2.2.3 Hydrogeologic Units

Hydrogeologic units in the facility vicinity correspond to litho-stratigraphic units. The five hydrogeologic units documented for this investigation are as follows: (1) Fill material; (2) Upper lacustrine deposits (3) Lower lacustrine deposits; (4) Glacial till; and (5) Dolomite aquifer. The majority of hydrogeologic characteristics for the first four units were collected during Phase II of the investigation. Since hydraulic characterization of the dolomite aquifer is beyond the scope of this investigation, information was obtained from bedrock wells within a one mile radius of the facility. Well logs for wells within a one-mile radius of the facility have been included in Appendix C. Laboratory and field methods were used to collect specific information on hydraulic conductivity, porosity, lithology, and grain size distribution for each unit.

Hydraulic conductivity values for the lacustrine and glacial till units have been estimated from laboratory and field permeability test methods. Porosity has been calculated from those samples on which laboratory permeability tests were performed. Lithology is considered in terms of heterogeneous vs. homogeneous geologic material, percentage of fine grained material, and plasticity. An interpretation of hydraulic connections can be made from the physical characteristics of the soil samples, data from temporary piezometers, and sound hydrogeologic principles.

2.2.3.1 Hydraulic Conductivity

Permeability characteristics of the glacial material were obtained from laboratory and field methods. The hydraulic conductivity of geologic units is likely to vary horizontally and

vertically. The degree of variation is dependent on the lithologic variation within the formation. The geometric mean of several hydraulic conductivity values from a single formation will give a better estimate of the formation hydraulic conductivity. Geometric means have been calculated for the lacustrine and glacial till units.

The laboratory method used was a falling head permeameter test. (ASTM #D-5084). Normally this test requires undisturbed samples that are collected with a thin walled tube (Shelby tube). Representative samples of the lacustrine deposits were obtained with Shelby tubes. However, several attempts to advance the sampler into the glacial till ended in refusal. Consequently, permeameter tests were performed on samples considered disturbed. The samples were collected with a split spoon sampler. Disturbed samples are distinguished from undisturbed samples by an asterisk. Laboratory permeability results are located in Appendix H.

Field methods included bail tests and slug tests performed on the temporary piezometers and RFI wells. When water is bailed from the well and the recovery of the water level is measured over time, the test is called a bail recovery test. When a cylinder is lowered into (or removed from) a well, and the change in water level is measured over time, the test is called a slug test. Hydraulic conductivity values were calculated by the Bouwer & Rice Method by the Aqtesolv® software package. Time-drawdown plots for the RFI wells are presented in Appendix F. Time-drawdown data and plots for the temporary piezometers can be found in Appendix G.

The Bouwer & Rice Method involves plotting drawdown versus time on a semilog graph. A line is fit through the data points and the slope of the line is used to calculate hydraulic conductivity. Theoretically, the data points lie along a straight line, but this is not always the case. A double straight line was frequently seen in slug and bail down time-drawdown plots. The first straight line at early times is a reflection of the permeable zone around the well (i.e., filter pack). The second straight line is more indicative of flow from the undisturbed aquifer into the well. The slope of the second straight line is used to calculate hydraulic conductivity (11).

Fill

The upper most water bearing unit is the fill material. This includes the active area of the site and the pier extending into Lake Calumet. Construction debris, slag, foundry sand, and other common fill materials were used to construct the land on which the facility is located. Soil samples collected during the drilling program during Phase I and Phase II were highly heterogeneous. A variety of clay, silt, sand, and gravel mixtures were found intermingled with wood, glass, slag, and rubble.

Hydraulic conductivity values for the fill material have been calculated from slug tests performed on 30 wells and piezometers each screened in the fill. Slug tests were repeated in three wells G-305, G-314, and G-330 as a means of checking the field procedure. For these wells the geometric mean of all tests has been calculated. The results have been tabulated in Table 2-1.

Hydraulic conductivity values of the fill material vary over a wide range, from 2.1×10^{-2} cm/sec at G-336 to 2.0×10^{-6} cm/sec at G-337. Hydraulic conductivity is a function of the fluid and the porous media. In each case the fluid is groundwater. The wide range of hydraulic conductivity values is due to the heterogeneous nature of the fill. As a result, an estimate of the average hydraulic conductivity value of the fill is not an accurate appraisal of conditions. Instead, the distribution of hydraulic conductivity values are shown in Figure 2-4. The histogram shows the frequency of occurrence for hydraulic conductivity values within each order of magnitude. Hydraulic conductivity values vary over 5 orders of magnitude. The most frequently occurring hydraulic conductivity values are within the 1×10^{-4} order of magnitude range.

TABLE 2-1
SLUG TEST RESULTS FOR FILL MATERIAL

WELL LOCATION	Hydraulic Conductivity		GEOMETRIC MEAN (cm/sec)	
	SLUG IN (cm/sec)	SLUG OUT (cm/sec)		
G-302	1.4 x 10 ⁻³	2.2 x 10 ⁻³	1.7 x 10 ⁻³	
G-303	4.4 x 10 ⁻⁴	2.5 x 10 ⁻³	1.1 x 10 ⁻³	
G-305 #1	5.9 X 10 ⁻⁶	3.9 x 10 ⁻⁶	4.8 x 10 ⁻⁶	5.15 x 10 ⁻⁶ (1)
G-305 #2	5.6 x 10 ⁻⁶	5.4 x 10 ⁻⁶	5.5 x 10 ⁻⁶	
G-307	2.2 x 10 ⁻⁴	2.5 x 10 ⁻⁴	2.3 x 10 ⁻⁴	
G-308	1.8 x 10 ⁻⁶	7.5 x 10 ⁻⁶	3.7 x 10 ⁻⁶	
G-314 #1	5.9 x 10 ⁻⁵	4.2 x 10 ⁻⁵	4.9 x 10 ⁻⁵	6.49 x 10 ⁻⁵ (1)
G-314 #2 (2)	1.1 x 10 ⁻⁴	--	--	
G-317	6.1 x 10 ⁻⁵	4.6 x 10 ⁻⁵	5.3 x 10 ⁻⁵	
G-318	1.6 x 10 ⁻⁶	2.8 x 10 ⁻⁶	2.1 x 10 ⁻⁶	
G-324	2.9 x 10 ⁻²	2.8 x 10 ⁻²	2.9 x 10 ⁻²	
G-324A	2.5 x 10 ⁻⁴	4.1 x 10 ⁻⁴	3.2 x 10 ⁻⁴	
G-330 #1	2.6 x 10 ⁻³	1.8 x 10 ⁻³	2.1 x 10 ⁻³	2.29 x 10 ⁻³ (1)
G-330 #2	2.5 x 10 ⁻³	2.4 x 10 ⁻³	2.5 x 10 ⁻³	
G-332	4.2 x 10 ⁻⁵	3.0 x 10 ⁻⁵	3.5 x 10 ⁻⁵	
G-334	4.8 x 10 ⁻⁴	5.0 x 10 ⁻⁴	4.9 x 10 ⁻⁴	
G-336	2.4 x 10 ⁻²	1.8 x 10 ⁻²	2.1 x 10 ⁻²	
G-337	3.9 x 10 ⁻⁶	1.1 x 10 ⁻⁶	2.0 x 10 ⁻⁶	
G-342	3.8 x 10 ⁻⁵	1.0 x 10 ⁻⁴	6.2 x 10 ⁻⁵	
G-343	6.4 x 10 ⁻⁴	6.5 x 10 ⁻⁴	6.4 x 10 ⁻⁴	
G-344	1.4 x 10 ⁻³	7.9 x 10 ⁻⁴	1.1 x 10 ⁻³	
G-347	2.6 x 10 ⁻⁴	2.9 x 10 ⁻⁴	2.7 x 10 ⁻⁴	
G-348	1.8 x 10 ⁻³	1.2 x 10 ⁻³	1.3 x 10 ⁻³	
G-349	2.0 x 10 ⁻⁴	2.3 x 10 ⁻⁴	2.2 x 10 ⁻³	
G-120S	5.6 x 10 ⁻⁴	5.3 x 10 ⁻⁴	5.5 x 10 ⁻⁴	

TABLE 2-1 (Cont.)

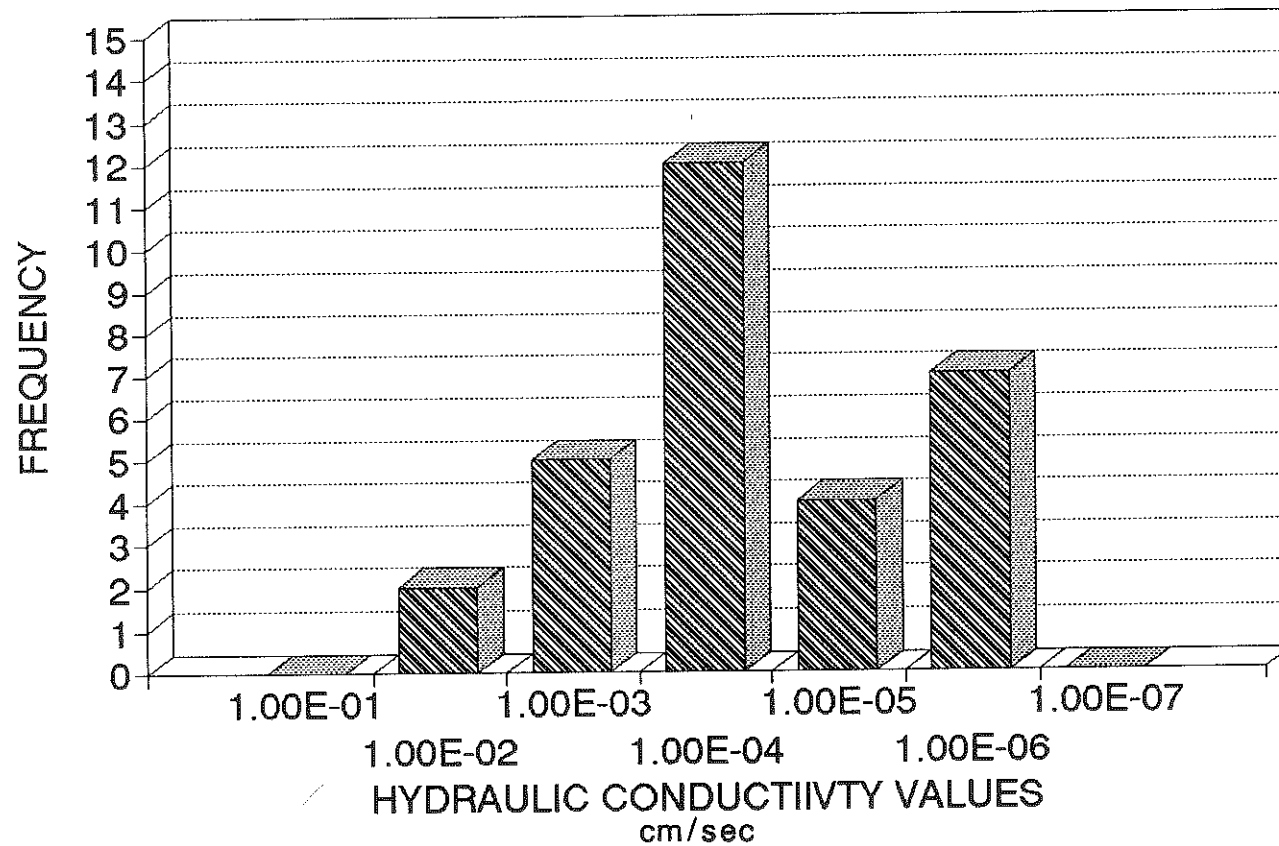
<u>WELL LOCATION</u>	Hydraulic Conductivity		GEOMETRIC MEAN (cm/sec)
	SLUG IN (cm/sec)	SLUG OUT (cm/sec)	
G-121S	3.4×10^{-6}	9.5×10^{-6}	6.1×10^{-6}
G-123S	1.5×10^{-4}	7.5×10^{-5}	1.1×10^{-4}
G-124S	1.4×10^{-6}	3.5×10^{-6}	2.2×10^{-6}
P-316	3.0×10^{-4}	4.5×10^{-4}	3.6×10^{-4}
P-319	3.4×10^{-4}	1.7×10^{-4}	2.4×10^{-4}
P-322 (3)	5.6×10^{-4}	1.2×10^{-3}	8.2×10^{-4}
P-323	3.4×10^{-4}	3.2×10^{-4}	3.3×10^{-4}
P-329	3.5×10^{-6}	1.5×10^{-6}	2.2×10^{-6}

(1) Geometric Mean of Both Trials.

(2) Slug in only on Trial #2.

(3) Both tests are Slug in.

RFI wells installed during Phase I of the investigation (October 1989).



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FIGURE 2-4
Histogram of Slug Test Results for Fill Material

DRN. BY: MG

PROJ. NO.: 13963-052-29

DATE: JUNE 1992

DAMES & MOORE

Upper Lacustrine

The upper lacustrine deposits are homogenous, and laterally continuous underlying the fill material. Laboratory permeability tests were performed on 5 samples collected during Phase I of the investigation and on 10 samples collected during Phase II. Bail recovery tests were performed on C-3PS and C-6PS, slug tests were run on C-2PS and C-2RPS. Results are summarized in Table 2-2.

Hydraulic conductivity values for laboratory permeability tests on these samples range from 1.97×10^{-8} cm/sec at B-341 (16-18 ft) to 2.0×10^{-7} cm/sec at P-319 (24-26 ft). Based on laboratory test results the geometric mean of the unit is 4.4×10^{-8} cm/sec. Hydraulic conductivity values from slug and bail recovery tests in piezometers screened in this layer range from 1.3×10^{-7} cm/sec at C-3PS to 3.4×10^{-7} cm/sec at C-2PS. The geometric mean of field hydraulic conductivity values is 2.3×10^{-7} cm/sec.

Similar hydraulic conductivity values were obtained from both field and laboratory permeability test methods. In general the laboratory values are lower than the field values. Laboratory permeability is a measure of the resistance to flow in the vertical direction (K_v), while field tests generally measure the horizontal hydraulic conductivity (K_h). Using the geometric mean values the ratio of the horizontal component of flow (K_h) to the vertical component of flow (K_v) is approximately 5 to 1. Different hydraulic conductivities along principle directions of flow is known as anisotropy. The upper lacustrine layer appears to be anisotropic since K_h is greater than K_v .

The primary cause of anisotropy is the orientation of the clay minerals. Clay content ranges from 34 to 62 percent, averaging 50 percent (< 0.005 mm). Clays seldom show $K_h:K_v$ ratios greater than 10:1, and are usually less than 3:1 (Freeze and Cherry p. 32). On a larger scale anisotropy is attributed to bedding. Horizontally bedded sediments such as lacustrine deposits are commonly transversely isotropic. In this case, anisotropy exists between the vertical

component of flow (z axis), and the horizontal components of flow (x and y axis). The horizontal components of flow are isotropic, roughly equal in both directions. However, it is important to note that groundwater flow is in only one direction, the resultant of the principle directions. The upper lacustrine layer is homogeneous and transversely isotropic, but vertically anisotropic.

TABLE 2-2
PERMEABILITY RESULTS OF UPPER LACUSTRINE UNIT

LOCATION	DEPTH (ft)	K (cm/sec)	SCREENED DEPTH (ft)	K average (cm/sec)
	Laboratory Permeability		Field Permeability	
C-1	27-29	2.3×10^{-8}		
C-2R	22-24	4.1×10^{-8}		
C-2PS			20-25	3.40×10^{-7}
C-2RPS			20-25	2.45×10^{-7}
C-3	24-26	2.8×10^{-8}		
C-3PS			18-23	1.32×10^{-7}
C-5	26-28	2.4×10^{-8}		
C-6	22-24	3.8×10^{-8}		
C-6PS			20-25	2.37×10^{-7}
C-7	29-31	2.2×10^{-8}		
D-1	26-28	2.3×10^{-7}		
D-2	17-19	4.2×10^{-7}		
D-3	22-24	2.9×10^{-8}		
D-3	30-31	3.1×10^{-8}		
B-304	20-22	1.4×10^{-7}		
G-318	20-22	3.9×10^{-8}		
B-P319	24-26	2.0×10^{-7}		
B-341	16-18	2.0×10^{-8}		
B-346	16-18	4.5×10^{-8}		
GEOMETRIC MEAN		4.4×10^{-8}		2.26×10^{-7}

Lower Lacustrine

Laboratory and bail recovery test results on the lower lacustrine deposits show a wider range of hydraulic conductivity values than the upper lacustrine deposits. Results have been summarized in Table 2-3.

**TABLE 2-3
PERMEABILITY RESULTS OF LOWER LACUSTRINE UNIT**

LOCATION	DEPTH (ft)	K (cm/sec)	SCREENED INTERVAL (ft)	K average (cm/sec)
	Laboratory Permeability		Field Permeability	
C-1	37-38.5	3.1×10^{-7}		
C-2	26-28	2.7×10^{-6}		
C-2*	36-38	6.8×10^{-7}		
C-2R*	31-31.5	1.6×10^{-5}		
C-2RPI			30-35	2.0×10^{-4}
C-3PI			29-34	4.3×10^{-6}
C-4	34-36	5.3×10^{-8}		
C-5	36-37.5	2.5×10^{-6}		
C-6PI			31-36	8.9×10^{-7}
D-2	27-29	2.9×10^{-8}		
GEOMETRIC MEAN		6.2×10^{-6}		9.1×10^{-6}

* Disturbed Sample

Laboratory permeability values range from 1.6×10^{-5} cm/sec at C-2R (31-31.5 ft) to 5.30×10^{-8} cm/sec at C-4 (35-36 ft) with a geometric mean of 6.2×10^{-6} cm/sec. Bail recovery results range from 2.0×10^{-4} cm/sec at C-2RPI to 8.94^{-7} cm/sec at C-6PI with a geometric mean of 9.1×10^{-6} cm/sec.

A wide range of hydraulic conductivity values is not unusual for a heterogeneous system. The lower lacustrine unit is composed of silt, silty clay, and clayey silt layers. Because it is so heterogeneous each layer in the sequence has a different hydraulic conductivity. Sand seams are also present and generally orders of magnitude more permeable than the silt and clay layers.

The lower lacustrine layer is an example of layered heterogeneity (Freeze & Cherry p.30). Individual layers each yielded values for hydraulic conductivity, but the entire system of layers is heterogeneous and anisotropic. Individual layers can be isotropic or anisotropic but the heterogeneity makes the unit as a whole anisotropic. This is best shown by temporary piezometer C-2RPI which is screened across a two foot thick sand lens. The bail recovery results yield a hydraulic conductivity of 2.0×10^{-4} cm/sec. The laboratory hydraulic conductivities above and below the sand lens are 1.6×10^{-5} and 6.8×10^{-7} cm/sec.

The hydraulic conductivities determined in the other temporary piezometers further support the conclusion that flow in the lower lacustrine layer is anisotropic. The wide range of hydraulic conductivity values not only vary with depth, but hydraulic conductivity varies laterally in the lower lacustrine layer. This is an indication that sand seams are discontinuous.

Glacial Till

Laboratory and field permeability tests of the glacial till also have low hydraulic conductivity values. Laboratory permeability tests were performed on seven soil samples and bail recovery tests were performed on the three temporary piezometers screened in the glacial till. Laboratory and field permeability tests are summarized in Table 2-4.

TABLE 2-4
PERMEABILITY RESULTS OF GLACIAL TILL

LOCATION	DEPTH (ft)	K average (cm/sec)	SCREENED DEPTH (ft)	K (cm/sec)
	Laboratory Permeability		Field Permeability	
C-1*	69-71	6.7×10^{-7}		
C-2RPD			53-58	3.6×10^{-7}
C-3*	44-46	1.1×10^{-6}		
C-3PD			49-54	1.5×10^{-7}
C-6*	42-44	7.9×10^{-7}		
C-6PD			53-58	1.7×10^{-7}
D-1*	34-36	2.3×10^{-8}		
D-1*	54-56	7.7×10^{-9}		
D-2*	57-59	2.3×10^{-7}		
D-3*	56-58	8.9×10^{-7}		
D-3*	72-74	4.9×10^{-9}		
GEOMETRIC MEAN		1.3×10^{-7}		2.1×10^{-7}

* Disturbed Sample

Laboratory hydraulic conductivity values range from 1.1×10^{-6} cm/sec at C-3 (44-46 ft) to 4.9×10^{-9} cm/sec at D-3 (72-74 ft) with a geometric mean of 1.3×10^{-7} cm/sec. Field hydraulic conductivity results show little variation with a geometric mean of 2.1×10^{-7} cm/sec.

Bail recovery tests are a measure of the hydraulic conductivity in the vicinity of the screened interval (horizontal component of flow) of the well being tested. These three tests indicate that there is not significant variation for hydraulic conductivities laterally. The glacial till unit as a whole is homogeneous in that the texture is heterogeneous. Very few sand and gravelly lenses

were encountered. For the most part the unit is 20-30% sand and gravel in a dense silty clay matrix.

Lab results vary over a wide range of low permeabilities. Explanations for this phenomena include clay content, degree of consolidation, disturbed samples, fractures, or any combination. The most likely reasons for the variations are a direct result of the composition of the soil. The till is predominantly clay (CL), silt (ML), or silty-clay (CL-ML) material based on the Unified Soil Classification System (USCS). The plasticity index is used to distinguish between CL, ML and CL-ML material. The plasticity index is influenced by the clay content. An increase in plasticity (i.e. clay content) generally indicates a decrease in permeability.

Variation of permeabilities may also be related to the degree of consolidation. The degree of consolidation has a significant influence on the permeability, and may be variable throughout the formation. Laboratory permeability is a measure of a smaller portion of the formation than bail recovery tests. In general, the till is very dense material, but "soft" zones may be present. However, the soil samples were collected as disturbed samples. Driving the sampler through the dense material may have affected the sample characteristics.

Fracturing in glacial till is not uncommon. Generally, fractures are present as microfractures. These in turn can cause increases in the vertical permeability of the formation. Since laboratory tests measure vertical permeability, the effect of microfractures would not be seen easily with bail recovery tests. Microfractures do not appear to have a significant impact on permeability of the glacial till. Lower vertical permeabilities are observed rather than higher when laboratory permeability test results are compared to slug test results.

The dolomite aquifer is the uppermost bedrock aquifer. It is also the uppermost aquifer that is capable of economic production of groundwater. Hydraulic conductivity estimates of the Silurian dolomite are based on information obtained from a nearby site. Hydraulic conductivities

from eight bedrock piezometers were provided in section E of the RCRA Part B Permit Application for Area 4 of the CID landfill, approximately 1.5 miles south of the site. Values range from 1.1×10^{-4} cm/sec to 2.1×10^{-5} cm/sec with geometric mean of 5.6×10^{-5} cm/sec. As stated in the Part B application, the variability of the hydraulic conductivity is a result of bedrock fractures.

The primary permeability (the permeability of the rock matrix) of most carbonate aquifers is often quite low. Fractures in the rock create a secondary permeability usually orders of magnitude greater than the primary permeability. The low permeability values of the Racine formation do not normally make it desirable for water supply. The transmissivity of the aquifer is large as a result of the thickness, not the hydraulic conductivity.

2.2.3.2 Physical Characteristics of Glacial Material

Porosity has been calculated from the samples on which laboratory permeability tests were performed. Laboratory permeability tests were performed on undisturbed samples collected from the underlying glacial material. (No undisturbed glacial samples of the fill were collected. Consequently, data needed to calculate the porosity of the fill is unavailable.) Results are summarized in Table 2-5. Laboratory measurements of the weight of the solids, final wet weight, and final saturated volume of the sample are needed to calculate porosity (see Appendix H). Porosity is estimated from the following relationships:

$$W_t = W_w + W_s$$

where:

W_t	=	Total weight of the sample
W_w	=	Weight of the water saturating the sample
W_s	=	Weight of the solids

The sample is weighed dry and weighed wet. The difference is the weight of the water. (It is assumed the final sample weight is 100% saturated. W_w is therefore the weight of water saturating the interconnected or effective pore spaces.)

$$V_v = \frac{W_w}{1g/cc}$$

where: V_v = Volume of the voids
 W_w = Weight of water
 1g/cc = the density of water

To convert from weight to volume divide by the density of water.

$$n = \frac{V_v}{V_t}$$

where: n = porosity (effective)
 V_v = Volume of the Voids
 V_t = volume of the saturated sample

To obtain the effective porosity, divide the volume of the voids by the total volume of the saturated sample.

Porosity values are listed in Table 2-5.

**TABLE 2-5
POROSITY OF GLACIAL MATERIAL**

LOCATION	DEPTH (ft)	POROSITY (%)
UPPER LACUSTRINE UNIT		
C-1	27-29	32.5
C-2R	22-24	35.0
C-3	24-26	34.3
C-5	26-28	35.6
C-6	22-24	33.4
C-7	29-31	34.7
D-1	26-28	36.3
D-2	17-19	36.0
D-3	22-24	37.6
D-3	30.5-31	31.3
LOWER LACUSTRINE UNIT		
C-1	37-38.5	28.6
C-2	26-28	39.5
C-2*	36-38	23.4
C-2R*	31-31.5	36.8
C-4	34-36	27.4
C-5	36-37.5	34.4
D-1	34-36	23.5
D-2	27-29	35.2
GLACIAL TILL		
C-1*	69-71	29.5
C-3*	44-46	26.3
C-6*	42-44	24.1
D-1*	34-36	23.5
D-1*	54-56	23.5
D-2*	57-59	26.4
D-3*	56-58	26.5
D-3*	72-74	24.1

* Disturbed sample

Porosity values are within the expected range for silt and clay. The 10 upper lacustrine samples ranged from 31.3% to 37.6% with an average of 34.7%. The 8 lower lacustrine porosity values ranged from 23.4% to 39.5%, averaging 31.1%. Porosity of the 8 glacial till samples ranged from 23.5% to 29.5% with an average of 25.5%. Porosity values were calculated from samples on which permeability tests were performed. These porosity values represent only the fine grained silt and silty clay material. Porosity values for sand typically range from 20% to 35%.

Typical of clay, the Upper Lacustrine unit has the highest porosity values, but the lowest permeabilities. The Lower Lacustrine unit has both porosity and permeability values that vary widely. This can be attributed to the heterogenous nature of the unit. Porosity values of the glacial till as a whole are lower than the lacustrine deposits.

The glacial deposits were divided into units based on the physical properties and the geologic origin of each unit. The lacustrine deposits have been further divided into an upper and lower unit based on physical characteristics and visual classification. The upper lacustrine layer is homogeneous. The lower lacustrine layer is heterogeneous. The upper lacustrine layer has a higher clay content. Representative samples were submitted for physical testing for confirmation. Physical properties of the soil samples have been summarized in the following tables. Soil testing results are presented in Appendix I.

TABLE 2-6
SOILS LAB DATA - UPPER LACUSTRINE UNIT

BORING LOCATION	DEPTH (ft)	USCS SYMBOL	ATTERBERG		MOISTURE CONTENT (%)	GRAIN SIZE DISTRIBUTION (%)				
			LL	PI		GRAVEL	SAND	SILT & CLAY	SILT	CLAY
B-304	20-22	CL	35	18	22.0	0	9	91	52	39
B-341	16-18	CL	38	19	24.0	0	2	98	59	39
B-346	16-18	CL	35	18	20.0	0	13	87	51	36
BP-319	24-26	CL	36	18	22.0	0	9	91	44	47
BG-318	20-22	CL	34	18	18.0	0	14	86	52	34
C-1	27-29	CL	33	16	19.2	4	13	83	33	50
C-1	31-33	CL	36	18	20.6	4	9	87	—	—
C-2R	22-24	CL	37	19	20.5	0	9	91	31	60
C-3	24-26	CL	37	18	19.5	0	11	89	27	62
C-5	26-28	CL	34	16	21.3	1	9	90	32	58
C-6	22-24	CL	35	17	20.3	0	14	86	31	55
C-7	29-31	CL	36	18	19.7	1	6	93	33	60
D-1	26-28	CL	35	16	21.7	0	11	89	29	60
D-2	17-19	CL	35	16	19.9	6	11	83	43	40
D-2	27-29	CL	36	17	16.1	0	10	90	42	48
D-3	22-24	CL	36	19	23.1	1	5	94	—	—
D-3	31-31.5	CL	37	18	20.0	1	7	92	—	—
RANGE			33-38	16-19	16.1-24.0	0-6	2-14	83-98	27-59	34-62
AVERAGE			35.6	17.6	20.5	1	9.6	89.4	39.1	50.4

TABLE 2-7
SOILS LAB DATA - LOWER LACUSTRINE UNIT

BORING LOCATION	DEPTH (ft)	USCS SYMBOL	ATTERBERG		MOISTURE CONTENT (%)	GRAIN SIZE DISTRIBUTION (%)				
			LL	PI		GRAVEL	SAND	SILT & CLAY	SILT	CLAY
B-328	26-28	ML								
C-1	37-38.5	ML	21	2	13.7	2	29	69	57	12
C-2	26-28	ML	26	3	24.0	0	0	100	83	17
C-2	28-30	ML	24	2	26.3	0	0	100	--	--
C-2	30-32	SM			23.8	0	85	15	--	--
C-2	36-38	CL	23	8	10.7	2	37	61	--	--
C-2R	30.5-31	ML			22.2	1	3	96	--	--
C-2R	31.5-32	SP-SM			12.1	4	86	10	--	--
C-3	30-32	ML	22	1	20.2	0	8	92	--	--
C-3	32-34	SM-SC			13.0	6	71	23	--	--
C-3	36-38	ML	22	3	13.2	2	25	73	--	--
C-3	40-42	SM			15.5	5	79	16	--	--
C-4*	32-34*	SM-SC			22.8	0	70	30	--	--
C-4	34-36	ML	21	3	14.3	2	26	72	49	23
C-5	30-32	SM			7.6	5	76	19	--	--
C-5	32-34	ML	26	2	23.4	0	2	98	--	--
C-5	36-37.5	ML	27	3	21.1	0	1	99	84	15
C-6	26-28	ML	22	2	17.3	0	6	94	--	--
C-6	32-34	ML			18.0	0	17	83	--	--
C-6	36-38	CL-ML	22	4	11.3	3	27	70	--	--

BORING LOCATION	DEPTH (ft)	USCS SYMBOL	ATTERBERG		MOISTURE CONTENT (%)	GRAIN SIZE DISTRIBUTION (%)				
			LL	PI		GRAVEL	SAND	SILT & CLAY	SILT	CLAY
C-7	35-37	CL-ML	22	5	14.5	0	27	73	—	—
D-1	30-32	ML	22	0	17.5	0	2	98	78	20
D-3	36-38	CL-ML	23	5	13.1	1	25	74	—	—
RANGE			21-27	0-8	7.6-26.3	0-6	0-86	10-100	49-84	12-23
AVERAGE			23.1	3.1	17.1	1.5	31.9	66.9	70.2	17.3

* Thin sand seam. See boring log in Appendix A for description.

TABLE 2-8
SOILS LAB DATA - GLACIAL TILL UNIT

BORING LOCATION	DEPTH (ft)	USCS SYMBOL	ATTERBERG		MOISTURE CONTENT (%)	GRAIN SIZE DISTRIBUTION (%)				
			LL	PI		GRAVEL	SAND	SILT & CLAY	SILT	CLAY
C-1	45-47	CL	23	7	11.5	5	28	67	--	--
C-1	53-55	CL	24	9	11.7	1	25	74	--	--
C-1	59-61	ML	17	0	17.9	2	25	73	--	--
C-2	69-71	CL	31	14	12.9	6	18	76	--	--
C-2	44-46	CL-ML	23	6	11.5	0	31	69	--	--
C-2	48-50	SM-SC			7.4	8	68	24	--	--
C-2R	38-40	SM-SC	24	7	10.4	16	53	31	--	--
C-2R*	40-42	SP-SM			11.7	31	58	11	--	--
C-2R*	42-44	SP-SM			16.7	25	67	8	--	--
C-2R	44-46	CL	23	8	12.4	2	26	72	--	--
C-2R*	50-52	SM-SC			9.6	0	70	30	--	--
C-2R	52-54	CL	25	9	8.7	4	30	66	--	--
C-2R	59-59.5	CL			21.3	1	11	88	--	--
C-3	44-46	CL-ML	23	7	11.7	2	29	69	--	--
C-3	50-52	CL	24	8	12.6	1	26	73	43	30
C-4	42-44	CL	28	12	14.3	1	26	73	--	--
C-4	48-50	CL	24	9	11.0	4	28	68	--	--
C-4	54-56	CL	23	7	11.6	2	20	78	--	--
C-4	64-66	CL	24	8	12.8	2	18	80	--	--
C-4	72-74	CL	29	12	13.8	2	17	81	--	--
C-5	44-46	CL	24	8	11.8	5	24	71	--	--
C-5	52-54	CL-ML	21	5	11.1	3	16	81	--	--
C-5	60-62	CL	26	9	12.4	2	17	81	--	--
C-5	68-70	CL	26	10	12.8	2	22	76	--	--

TABLE 2-8 (Cont.)

BORING LOCATION	DEPTH (ft)	USCS SYMBOL	ATTERBERG		MOISTURE CONTENT (%)	GRAIN SIZE DISTRIBUTION (%)				
			LL	PI		GRAVEL	SAND	SILT & CLAY	SILT	CLAY
C-6	44-46	CL-ML	21	7	11.3	5	28	67	--	--
C-6	52-54	ML	21	3	13.4	0	11	89	--	--
C-7	41-43	CL-ML	23	7	11.9	1	29	70	--	--
C-7	47-49	CL-ML	22	6	10.3	4	27	69	--	--
C-7	51-53	CL-ML	22	6	11.4	1	24	75	--	--
C-7	59-61	CL	26	10	10.3	2	18	80	--	--
C-7	66-68	CL	25	9	11.7	1	19	80	--	--
D-1	38-40	CL	24	9	13.4	0	30	70	--	--
D-1	46-48	CL	24	8	11.1	2	32	66	--	--
D-1	54-56	CL-ML	26	7	11.4	4	22	74	--	--
D-1	62-64	CL	29	12	14.0	0	16	84	39	45
D-1	72-74	CL	23	8	9.2	23	23	54	--	--
D-2	35-37	CL-ML	23	5	11.0	2	33	65	--	--
D-2	43-45	CL	26	11	13.2	1	27	72	--	--
D-2	51-53	ML	22	3	14.8	0	10	90	--	--
D-2	59-61	ML	20	3	15.7	0	31	69	--	--
D-2	67-69	SM-SC	20	6	7.5	5	60	35	--	--
D-2	74.5-76.5	CL-ML	24	6	14.2	0	10	90	--	--
D-3	42-44	CL	24	8	12.8	2	27	71	--	--
D-3	50-52	CL	24	8	11.2	4	31	65	--	--
D-3	56-58	CL				1	19	80	--	--
D-3	64-66	CL	25	8	10.9	1	19	80	--	--
D-3	72-74	CL				2	24	74	--	--
RANGE			17-31	0-14	7.4-21.3				--	--
AVERAGE			23.9	7.6	12.2				--	--

* Thin sand seam. See boring logs in Appendix B for description.

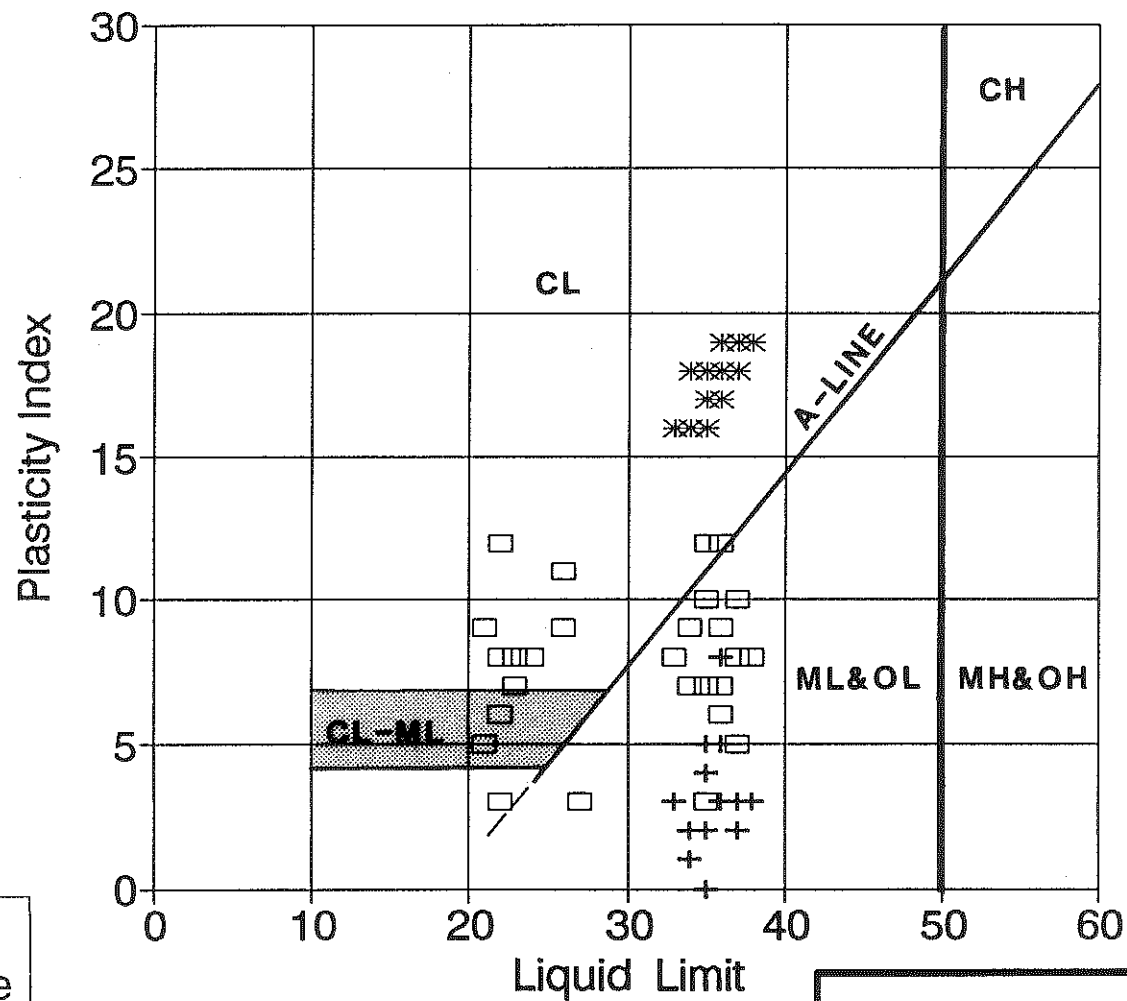
The upper lacustrine layer represents quiet water lake deposits. The unit is a homogeneous light gray, silty clay. Some fine sand and scattered gravel is present. Silt and clay content ranges from 83% - 98%, averaging 89.4%. The clay content ($<0.005\text{mm}$) ranges from 34 to 62% averaging 50.4%.

The lower lacustrine layer is heterogeneous, composed of layers of silty clay, clayey silt and silt with interbedded seams of silty sand and sand. The silt and clay content ranges from 10 to 100%, averaging 66.9%. Clay content ranges from 12-23% averaging 17.3%.

The glacial till is composed of a silty clay or clayey silt homogeneous matrix with varying amounts of sand and gravel. Gravel content ranges from 0-13%, averaging 4.0%. Sand content ranges from 10 to 70% averaging 28.2%. Silt and clay content ranges from 8% to 90% averaging 67.8%. Clay content from two samples ranges from 30-45% averaging 37.5%. The unit as a whole is a dense, silty clay matrix containing 20-30% sand and gravel. Few thin sand lenses were also encountered.

The lower lacustrine layer has physical properties similar to the glacial till. The different modes of deposition distinguish the two layers. The lower lacustrine layer represents sediment eroded from the till and redeposited in shallow Lake Chicago by wave erosion.

Atterberg limits performed on the soil are used to evaluate soil behavior. The liquid limit is the percent moisture content below which the soil behaves as a plastic medium. The soil behaves as a liquid above the liquid limit. The plastic limit is the percent moisture content below which the soil behaves as a solid. The soil behaves as a plastic above the plastic limit. The difference between the liquid limit and plastic limit is the plasticity index. This is the range of water content over which a soil behaves with plasticity. A soil is classified by plotting the liquid limit versus the plasticity index on a plasticity chart. The region on which the soil plots determines the USCS classification. Figure 2-5 is a plasticity chart for the 3 glacial units.



✱
 Upper Lacustrine
 +
 Lower Lacustrine
 □
 Glacial Till

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CHICAGO INCINERATOR

FIGURE 2-5
Range of Plasticity Values for Glacial Deposits

DPN. BY: MG

PROJ. NO.: 13963-052-29

DATE: JUNE 1992

DAMES & MOORE

The upper lacustrine unit soil samples plot as a cluster on the chart. This indicates the clay is consistent and homogeneous throughout the unit. The lower lacustrine and glacial till samples plot over a wider range. This confirms the heterogeneous nature of these units.

2.2.3.3 Hydraulic Connections Between Hydrogeologic Units

The transmission of groundwater between hydraulic units is a function of the physical properties of the porous media and the hydraulic gradient. The two most significant physical properties are the hydraulic conductivity and porosity. Hydraulic conductivity is a measure of the resistance of flow dependent on the porous media and fluid properties of the groundwater. Groundwater flow is through the pore spaces, and the hydraulic gradient is the driving force. This relationship is shown by the following equation for seepage velocity:

$$V = \frac{Ki}{n_e}$$

where:

- V = the average linear groundwater flow velocity along flow lines.
- K = the hydraulic conductivity.
- i = the hydraulic gradient. (The difference in water elevation, or head, divided by the length over which the head is measured)
- n_e = the effective porosity.

Hydraulic conductivities for each unit have been estimated from field and laboratory testing at numerous locations. The geometric mean of these values is representative of the hydraulic conductivity of the unit. Effective porosity values have been estimated from laboratory measurements.

Hydraulic gradients have been calculated from nested piezometers. RFI piezometers were installed in the fill material during Phase I of the investigation. The fill material is the uppermost water bearing unit and behaves as an unconfined aquifer. Temporary piezometers

were installed in the glacial material during Phase II of the investigation to measure the fluid pressure of the aquitard. The units behave as confined aquifers with fluid pressures showing strong downward gradients.

Piezometer nests were installed at four locations and at three horizons. Shallow piezometers were installed in the upper lacustrine layer (C-2PS, C-2RPS, C-3PS, and C-6PS). Intermediate piezometers were installed in the lower lacustrine layer (C-2PI, C-2RPI, C-3PI, and C-6PI). Deep piezometers were installed in the glacial till (C-2RPD, C-3PD, and C-6PD). These piezometers are shown in Geologic cross-section A-A¹ in Figure 2-3. Well construction forms for the temporary piezometers have been included in Appendix E.

C-2R and C-3 piezometer nests yielded the most complete results since they are adjacent to RFI piezometers screened in the fill. Vertical gradients are calculated between four hydrogeologic units since each unit has a piezometer. Vertical gradients between the four hydrogeologic units are shown in Table 2-9 for piezometers at the C-2R and C-3 locations. The negative sign is used to indicate the direction of flow. Upward flow is positive, while downward flow is negative.

TABLE 2-9

VERTICAL HYDRAULIC GRADIENTS BETWEEN HYDRAULIC UNITS

C-2R \ P-322 LOCATION				
	P-322	C-2RPS	C-2RPI	C-2RPD
P-322	-	-	-	-
C-2RPS	- 0.14 ft/ft	-	-	-
C-2RPI	- 0.42 ft/ft	- 0.89 ft/ft	-	-
C-2RPD	- 0.39 ft/ft	- 0.52 ft/ft	- 0.36 ft/ft	-
C-3 \ P-323 LOCATION				
	P-323	C-3PS	C-3PI	C-3PD
P-323	-	-	-	-
C-3PS	- 0.06 ft/ft	-	-	-
C-3PI	- 0.51 ft/ft	- 0.93 ft/ft	-	-
C-3PD	- 0.51 ft/ft	- 0.65 ft/ft	- 0.51 ft/ft	-

Vertical gradients of C-2 and C-6 locations are not included in this table. Vertical gradients are most likely similar since water levels in C-2 and C-6 are similar to water levels in C-2R and C-3. The only exception is C-6PS. This shallow piezometer has a water level much lower than expected. This phenomenon is most likely the result of bentonite plugging the screen. On November 13, 1991 C-6PD and C-6PS were damaged by equipment. The PVC was broken above the surface at C-6PD, but below the surface at C-6PS. Bentonite surface seal material may have fallen into the well. The damage occurred before a representative water level could be obtained.

Table 2-9 shows a similar pattern between vertical gradients at the C-2R and C-3 locations. Vertical gradients are downward, but range widely in intensity. Slight downward gradients exist between the fill and upper lacustrine layer (RFI piezometer and shallow piezometer). The

strongest gradients exist between the shallow and intermediate piezometers screened in the upper and lower lacustrine units. The next strongest gradient exists between the shallow piezometer and the deep piezometer. The remaining gradients are approximately equal as follows: 1) The RFI piezometer and the intermediate piezometer (i.e., -0.51 ft/ft between P-323 and C-3PI); 2) The RFI piezometer and deep piezometer (i.e., -0.51 ft/ft between P-323 and C-3PS), and, 3) the intermediate and deep piezometer (i.e., -0.51 ft/ft between C-3PI and C-3PD). A vertical gradient of 0.5 ft/ft is near the upper limits of gradients observed in dense fine grained glacial till and glaciolacustrine deposits. (Freeze and Cherry p.151). It is important to note that the upper lacustrine layer has the greatest impact on vertical gradients.

The occurrence of strong downward vertical gradients and the downward direction of groundwater flow are directly related to the physical properties of the soil. The fine grained low permeability glacial units not only function as a confining unit for the bedrock aquifers, but also restrict the downward flow of groundwater. Surface water in Lake Calumet and groundwater in the saturated fill unit are perched above the upper lacustrine layer. The strong downward vertical gradients represent head losses across a low permeability barrier. The direction of groundwater flow is downward because the path of least resistance is also the shortest path vertically across the barrier. Consequently, an extremely low rate of groundwater flow is present across the barrier. Using the average vertical hydraulic conductivity ($k_v = 4.3 \times 10^{-8}$ cm/sec), average porosity of 34.7%, and vertical gradient of -0.9, the seepage of groundwater through the upper lacustrine layer is 1.1×10^{-7} cm/sec based upon the equation

$\bar{v} = \frac{ki}{n}$. This is approximately 3.47 cm/year.

2.2.4 Groundwater Migration Pathways

Groundwater, fill, soil, surface water, Lake Calumet sediment, and clay samples collected during both phases of the investigation indicate that contamination is principally limited to the

fill material. The uppermost water bearing unit is also in the fill material. Potential contaminant migration pathways include: (1) downward vertical migration, and (2) horizontal migration through the fill material into Lake Calumet. Each potential migration pathway is discussed below.

2.2.4.1 Downward Vertical Migration Pathways

As discussed in previous sections, the glacial material underlying the fill material consists of fine grained low permeability soils. Vertical gradients measured between piezometers screened in the fill and underlying glacial units were described in Section 2.2.3.3. Strong downward vertical gradients exist because the upper lacustrine layer is behaving as a barrier to groundwater flow. The direction of groundwater flow is vertical, but insignificant in magnitude. A vertical seepage velocity of 3.47 cm/year was calculated in Section 2.2.3.3. The downward direction of groundwater flow is related to the low permeability of the upper lacustrine unit. A vertical groundwater flow direction exists because this is the direction of least resistance. Groundwater always flows in the direction of least resistance. Consequently, groundwater seepage into the underlying bedrock units is restricted by the fine grained low permeability glacial deposits. The upper lacustrine unit is behaving as a barrier to contaminant migration.

2.2.4.2 Horizontal Migration of Groundwater Through the Fill

Initial inspection of groundwater elevations and flow directions in the uppermost water bearing unit indicate that groundwater is discharging to Lake Calumet. This phenomenon has been further evaluated in Section 4.2.5.

2.2.5 Groundwater Elevations

The RFI wells are all screened in the uppermost water bearing unit (the fill). Several rounds of water levels have been collected during Phase I and Phase II of the investigation. Six rounds of groundwater elevations from 30 RFI wells and piezometers are summarized in Table 2-10. The first round collected in Phase I (Oct. 19, 1989) are from RFI wells installed at that time.

TABLE 2-10
GROUNDWATER ELEVATIONS IN RFI WELLS

WELL LOCATION	PHASE I		PHASE II			
	OCT. 19, 1989	NOV. 20, 1989	DEC. 2, 1991	JAN. 8, 1992	FEB. 25, 1992	MAR. 31, 1992
G-120S(1)	-	5.49	4.33	3.56	3.29	3.76
G-121S(1)	-	4.01	6.39	5.44	5.55	5.73
G-123S(1)	-	6.98	8.23	7.86	7.94	8.11
G-124S(1)	-	4.12	4.30	3.84	3.97	4.03
G-302	-0.87	-0.97	-0.52	0.43	-0.39	-0.48
G-303	1.61	2.55	2.57	2.33	2.57	2.39
G-305	2.63	0.07	1.88	1.10	1.29	1.73
G-307	3.69	6.17	7.09	6.07	6.47	6.54
G-308	4.07	4.75	6.33	6.06	6.06	6.26
G-314	3.93	4.98	5.07	5.08	5.03	5.37
G-317	-	9.40	9.84	10.18	10.75	10.61
G-318	-1.76	2.18	3.57	3.17	2.38	2.59
G-324	-	0.58	1.56	1.10	-	-
G-324A (2)	1.95	0.37	1.09	0.69	1.09	0.72
G-330	2.96	3.72	4.02	3.56	3.90	3.75
G-332	6.13	7.66	7.81	7.56	7.72	7.94
G-334	5.70	7.08	7.01	6.82	6.92	7.19

WELL LOCATION	PHASE I		PHASE II			
	OCT. 19, 1989	NOV. 20, 1989	DEC. 2, 1991	JAN. 8, 1992	FEB. 25, 1992	MAR. 31, 1992
G-336	-	0.33	1.19	0.69	0.65	0.55
G-337	0.70	0.55	0.53	0.36	0.14	0.49
G-342	0.68	-0.16	0.38	0.41	0.41	0.45
G-343	-	6.27	6.74	6.72	6.72	6.78
G-344	3.92	4.06	5.45	4.60	4.67	4.83
G-347	5.61	5.78	6.73	6.70	6.65	6.87
G-348	4.66	4.68	6.60	7.00	5.65	5.81
G-349	5.08	5.81	7.35	6.44	6.66	6.97
P-316 (2)	-	9.46	11.15	10.26	10.82	10.66
P-319 (2)	1.31	1.91	2.48	2.47	2.48	2.49
P-322 (2)	6.94	7.11	8.45	8.05	8.14	8.50
P-323 (2)	5.20	6.18	7.71	7.28	7.56	7.96
P-329 (2)	3.67	3.93	4.10	3.70	3.81	4.02

- (1) Groundwater monitoring wells installed as part of the ongoing site groundwater assessment.
(2) No water quality samples collected. Used only to measure water levels.

NOTE: Above elevations reported as Chicago City Datum. Chicago city datum begins at the approximate elevation of Lake Michigan = 579.88 feet above mean sea level which is equal to 0 Chicago City Datum.

The remaining wells were installed prior to the second round (Nov. 20, 1991). Well construction forms from the RFI wells have been included in Appendix D. Phase II groundwater elevations were collected monthly from December 1991 to March 1992. Groundwater elevation maps have been prepared from both Phase I and Phase II of the investigation. Figure 2-6 is a water table map of groundwater elevations collected during Phase I. Figure 2-7 is a water table map from Phase II of the investigation. It should be noted that the vault is not in hydraulic connection with the Fill unit. Consequently, a potentiometric surface in the area of the vault is absent.

Minor seasonal fluctuations of groundwater elevations over time have been observed. Since the Fill unit is in direct hydraulic connection with Lake Calumet, fluctuations in lake levels will be reflected in the RFI wells. The lake level is controlled by the locks along the Cal-Sag Channel. These locks have held lake levels fairly constant over the past several years. Lake levels experienced minor fluctuations during the investigation, and were likely due to these man-made influences.

Groundwater elevations yield the same flow pattern between Phase I and Phase II. The highest elevations are found in the eastern property and are centered along the long axis of the pier. This indicates that localized groundwater flow is towards Lake Calumet.

The most significant aspect of the groundwater surface is the presence of groundwater mounds. Groundwater mounds exist in the areas of the former biobeds (SWMU #1) and wastewater basin #2 (SWMU #6). Fine grained low permeability material used to line the former wastewater basins is restricting the flow of groundwater. Infiltrating precipitation causes head build up in the fill material which was used to backfill the former wastewater basins.

Temporary piezometers were installed at four locations during Phase II of the investigation. Piezometers were installed at shallow, intermediate, and deep horizons in the glacial material. The shallow piezometers were installed in the Upper Lacustrine unit, intermediate piezometers in the Lower Lacustrine unit, and deep piezometers in the glacial till. Geologic cross sections A-A' and B-B' (Figure 2-3) show piezometer locations and groundwater elevations. Final piezometer groundwater elevations were measured on March 31, 1992 and are summarized in Table 2-11. These groundwater elevations show a steady rise in water levels after development. Note that these levels, which represent static levels, were collected four months following piezometer installation and development. Well development information is included on well construction forms in Appendix E.

TABLE 2-11
GROUNDWATER ELEVATIONS IN TEMPORARY PIEZOMETERS
LEVELS MEASURED MARCH 31, 1992

WELL LOCATION	GROUNDWATER ELEVATION	TOP OF PVC ELEVATION	BOTTOM ELEVATION
P-322	8.50	11.63	1.4
C-2RPS	6.21	12.39	-15.5
C-2RPI	-2.79	11.41	-25.6
C-2RPD	-11.17	11.54	-48.7
C-2PS	6.37	12.65	-15.3
C-2PI	(1)	12.53	-26.3
P-323	7.96	11.49	-3.4
C-3PS	7.35	12.27	-13.7
C-3PI	-2.77	12.31	-24.6
C-3PD	-12.95	12.60	-44.7
C-6PS	-1.80	11.84	-15.4
C-6PI	-1.80	12.60	-26.4
C-6PD	-16.32	10.32	-49.2

(1) Interference of water level caused by methane gas.

NOTE: Above elevations reported as Chicago City Datum. Chicago City Datum begins at the approximate elevation of Lake Michigan. 579.88 feet above mean sea level is equal to 0 Chicago City Datum.

The temporary piezometers indicate strong downward vertical gradients. As previously discussed in Section 2.2.3.3, the strongest gradients exist between piezometers screened in the Upper Lacustrine and Lower Lacustrine units. The smallest vertical gradients exist between the wells screened in the fill and piezometers screened in the Upper Lacustrine unit. The upper lacustrine layer has the most significant impact on vertical gradients. Remaining vertical gradients between other piezometers are similar. Head losses across a low permeability barrier are responsible for the strong vertical gradient across the Upper Lacustrine unit. The fine-grained low permeability Upper Lacustrine unit will not readily transmit groundwater. Energy (i.e., head) is lost across this boundary resulting in strong downward vertical gradients. The low vertical gradient between the Fill and Upper Lacustrine units indicate that the Fill unit behaves as a perched aquifer.

2.2.7 Manmade Factors Influencing the Groundwater Flow Regime

Manmade factors do not have a significant impact on the groundwater flow regime. Groundwater is not withdrawn from the uppermost water bearing fill unit. The uppermost aquifer capable of commercial production of groundwater is the dolomite bedrock aquifer. This is separated from the fill material by 60 to 65 feet of fine grained low permeability glacial deposits. The glacial deposits behave as a confining unit for the bedrock aquifer. Consequently, water levels in the fill material are not affected by a decline in the potentiometric surface of the bedrock aquifer.

The fill material is in direct hydraulic connection with Lake Calumet. Fluctuations in lake levels will be reflected in the RFI wells. The elevation of the lake is controlled by the locks along the Cal-Sag Channel. The locks have held the elevation of Lake Calumet fairly constant over the past several years. Only minor fluctuations in both lake and groundwater levels have been observed.

2.3 Soils

No naturally-occurring soils are present above the uppermost water bearing unit at the facility. The Chicago Incinerator Facility and former SWMUs were all constructed on the fill material. The uppermost naturally-occurring soil beneath the facility is the upper lacustrine unit previously discussed in Section 2.2.3.

2.4 Surface Water and Sediment

Surface water features present on-site include four interim status surface water impoundments for which an interim status closure plan was submitted to the Illinois Environmental Protection Agency on March 16, 1992. These impoundments were originally used for process water and stormwater storage. These impoundments were replaced by four above ground storage tanks in November 1988. No natural streams cross or adjoin the property and there are no wetland areas within the site boundaries.

None of the areas within the site boundaries are located within a 100-year floodplain. According to Flood Insurance Rate Maps of the area, published by the National Flood Insurance Program, the areas of the pier and active incinerator operations are identified as areas of minimal flooding.

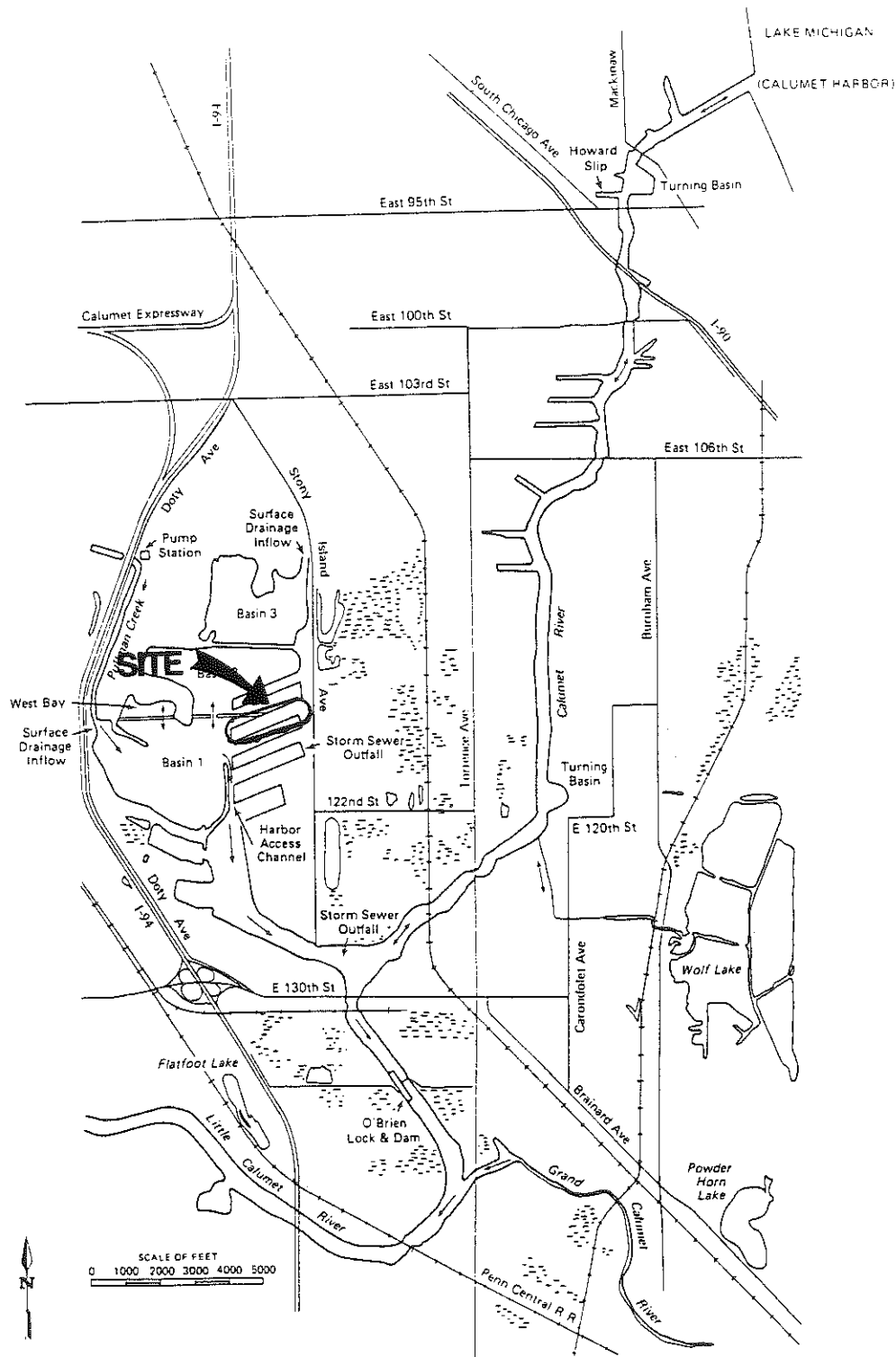
The nearest natural surface water body to the site is Lake Calumet, which borders the site on the west and partially on the north and south. Precipitation falling on the pier area follows natural topography, with overland flow toward Lake Calumet. Precipitation falling on paved areas of the site in the active incinerator process area is directed toward a sump, where the flow is routed through a pipe to the stormwater storage tank. Although sediment loading to Lake Calumet from the site was not measured during this investigation, sediment loading from the pier is anticipated to be relatively insignificant due to the presence of vegetated grassy areas combined with the level topography of the pier. Precipitation falling on the tank farm located

on the south side of the incinerator process area and other containment areas on-site, is analyzed and a determination is made by CWMCS as to whether the water is to be managed as stormwater or as hazardous waste. These areas are surrounded by a concrete secondary containment system which was constructed and maintained in accordance with the requirements of 40 CFR parts 265.193(6) and 761.65. Precipitation falling into the secondary containment structure is collected and pumped into above ground tanks for additional treatment prior to discharge to the MWRDGC sewer system.

The Lake Calumet area is shown on Figure 2-8. The surface elevation of Lake Calumet is 0 feet, Chicago City Datum, which corresponds to 579.88 feet above MSL. According to Ross, et al., the surface area of Lake Calumet is approximately 782 acres and receives surface drainage from a watershed area of approximately 3,700 acres, including the lake. Land use in the watershed consists of waste management operations (landfills and treatment facilities), industries, and highways. Lake depths vary from approximately 5-10 feet in the basin area west of the site to a depth of 30-35 feet in the dredged harbor area south of the site. Figure 2-9 shows a lake bed profile of the lake basin to the west of the site.

Hydrological reports indicate flow patterns in the lake are often complicated by wind direction, precipitation, the opening and closing of the O'Brien Lock and Dam, and water level interactions with nearby water bodies, including the Calumet, Little Calumet and Grand Calumet Rivers, and Lake Michigan (Ross, et al.) (Fitzpatrick). Generally however, flow through the lake trends in a north to south direction with drainage occurring from Lake Calumet into the Calumet River and beyond to Lake Michigan.

Three major sources of inflow into Lake Calumet are also shown in Figure 2-8. Pullman Creek enters at the lake's west-central bank, approximately one (1) mile west of the CWMCS facility. The creek, a man-made drainage ditch named after the neighborhood from which it flows,



SOURCE: HAZARDOUS WASTE RESEARCH AND INFORMATION CENTER, ILLINOIS STATE WATER SURVEY DIVISION, POLLUTANT TRANSPORT TO LAKE CALUMET AND ADJACENT WETLANDS AND AN OVERVIEW OF REGIONAL HYDROLOGY.

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**FIGURE 2-8
LAKE CALUMET AREA**

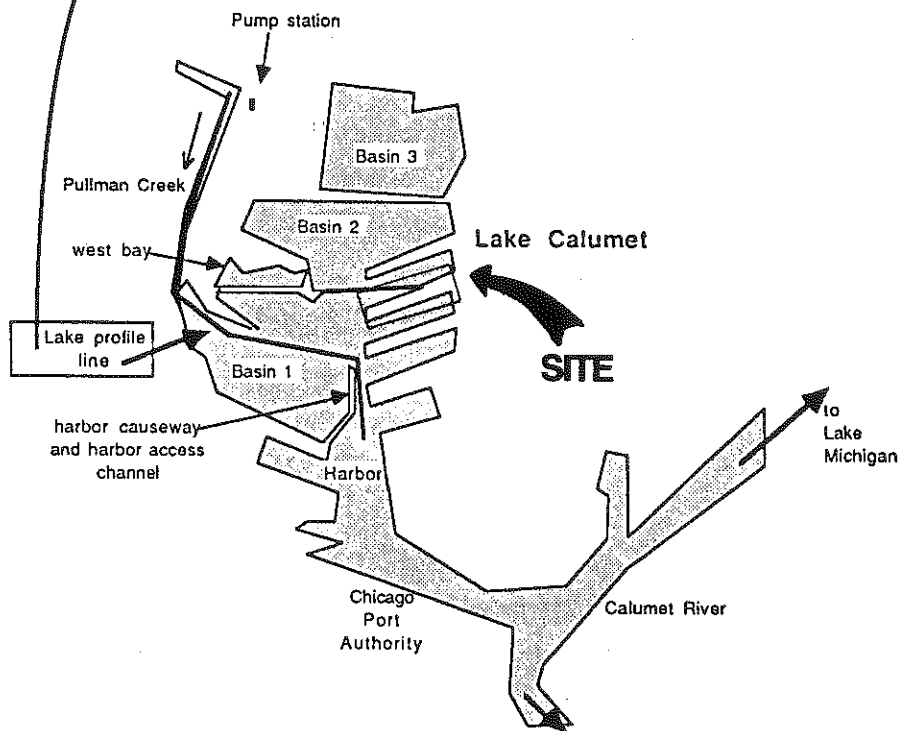
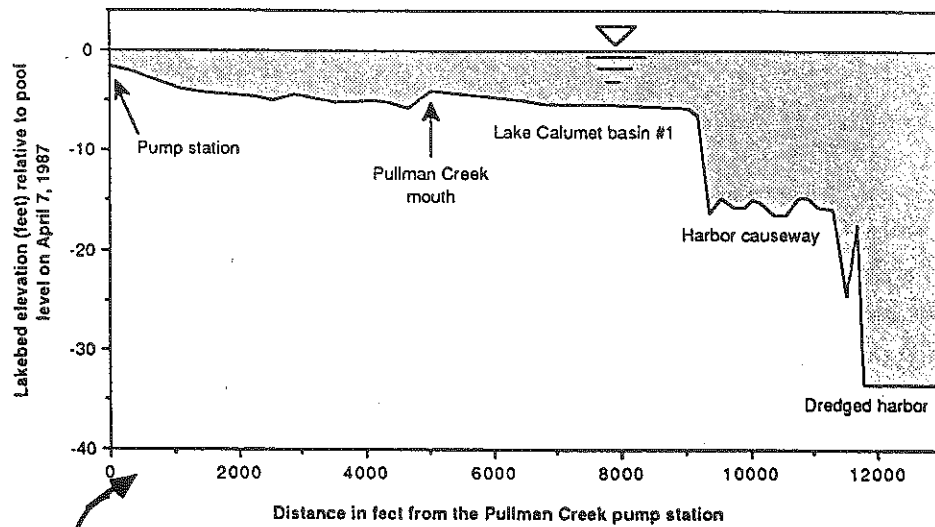
DRN. BY MMS

PROJ. NO. 13963-052-29

DATE OCTOBER 1993

DAMES & MOORE

Lake Calumet profile from the pump station to Calumet Harbor
April 16, 1987



SOURCE: HAZARDOUS WASTE RESEARCH AND INFORMATION CENTER, ILLINOIS STATE WATER SURVEY DIVISION, A PRELIMINARY ENVIRONMENTAL ASSESSMENT OF THE CONTAMINATION ASSOCIATED WITH LAKE CALUMET COOK COUNTY, ILLINOIS

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FIGURE 2-9
Bed Profile of Pullman Creek and Lake Calumet

DRN. BY: MG

PROJ. NO.: 13963-052-29

DATE: JUNE 1992

DAMES & MOORE

conveys storm water runoff from numerous drainage ditches and from the Illinois Department of Transportation's storm sewer system pump station located near the intersection of Pullman Creek and Interstate Highway I-94. A second major man-made drainage channel enters the lake in the lake's northeast corner. As shown in Figure 2-8, additional storm sewer outfalls are located at the end of the boat slip located approximately 1,000 feet south of the CWMCS facility, and near the outlet of the lake, where the lake adjoins the Calumet River. Reports indicate other outfalls may exist and may be discharging into the lake as well (Ross, et al).

Available discharge information indicates the discharge rate at the Lake Calumet harbor access channel on April 16, 1987 was 306 million gallons per day. This rate was qualified as likely much larger than the average flow rate due to a storm event and wind-induced circulation that was taking place at the time the measurement was made (3).

Sediment loading into Lake Calumet from Pullman Creek over a nine-day period, April 7 to 16, 1987, was estimated in an earlier report from sonar profiles made on the two surface water bodies (Ross et. al.). The results indicated 2,500 cubic feet of sediment (approximately 44 tons) had been deposited into the lake from Pullman Creek. Also observed during this period was the re-suspension of previously deposited bottom sediments and scouring to a depth of several feet below the surrounding lakebed caused by the increased flow velocities between Basins 1 and 2, and between Basin 1 and West Bay (see Figure 2-9 for basin and bay locations). The results of this study indicate that significant flow and movement of sediment are occurring between Pullman Creek and Lake Calumet and between the connected basins of the lake. The scouring, re-suspension, and deposition of bottom materials is a significant source of pollutants and an important mechanism for pollutant transport in Lake Calumet (Ross, et al.).

Thickness and physical deposits of lake sediments as encountered in borings penetrating the site pier have been previously discussed in Section 2.2.3.

2.5 Methane Gas

2.5.1 Occurrence of Methane Gas

Methane gas was encountered within the clay borings at isolated locations during Phase II of the CWM Chemical Services Chicago Incinerator RFI. An interim report was prepared to present data collected on the soil materials collected below the fill (1). The focus of this interim report is on findings made on the deep soil material underlying the fill, which includes the clay, as well as other glacial deposits.

The methane was restricted to borings advanced within the biobed area. The first occurrence was in a 2-foot silty sand seam between 30 and 32 feet in boring C-2 (Figure 2-3). Concentrations of methane were measured in the borehole in excess of the LEL, temporarily stopping work. The gas subsequently dissipated as water infiltrated the borehole. Levels of methane were then encountered above the LEL in the same borehole at the 48 to 50 foot interval when a second silty sand seam (from 49-50 feet) was intersected. The boring remained open at this depth with no water infiltration, allowing the methane to vent. Methane at a concentration of 80% was measured at a pressure of approximately 10 psig. As a result, the borehole was abandoned for safety reasons. The -40 foot clay sample and corresponding piezometer were not completed. Temporary piezometers were installed in adjacent boreholes at the shallow and intermediate depths corresponding to the -5 and -15 foot intervals. Following well development, levels of methane in C-2PI (the -15 foot depth) were measured at 75% at a gas pressure of 9.5 psi.

A replacement boring was later advanced near the original C-2 location. The boring was labeled C-2R located 25 feet northwest of C-2. Clay samples were collected at the -5, -15, and -40 foot intervals below the fill-clay contact. Three temporary piezometers were installed in adjacent boreholes at corresponding depths. Levels of methane were measured in the borehole in excess of the LEL when a sand seam at 30 to 32 feet was penetrated. The methane was again under

pressure. Work was halted, and the gas dissipated after a short period. Although a 3 inch silty sand seam was encountered at the C-2R 48-50 foot depth interval, the borehole was completed without encountering methane.

Temporary piezometers were installed at the same depth intervals as C-2R at the C-3 and C-6 locations in the biobed area. No methane was encountered during drilling, but methane was measured in virtually all of the temporary piezometers following development. Because of the slow recharge rate in these piezometers, methane most likely entered the well when the screen was exposed to air. It is important to note that the high pressures under which the methane vented at C-2 and C-2R was not seen at any other location. Methane discharging from the temporary piezometer C-2I dissipated after several months.

On January 20, 1992, samples of methane were collected from nine of the temporary piezometers and sent to the Illinois State Geological Survey (ISGS) for isotope dating. Samples from 6 RFI wells in the Biobed area were also sent, but no methane was detected. The methane was analyzed for C_{12} and C_{13} isotopes. The ratio of C_{12} to C_{13} is used to determine the origin of the methane. C_{12} to C_{13} ratios present in the methane did not fall within normal ranges of landfill gas or glacial drift gas. The ISGS, therefore, recommend C_{14} dating. Five piezometers, previously shown to have an adequate concentration of methane, were sampled again on April 3, 1992. Once the methane gas was determined to be naturally occurring, the ISGS collected another round of methane samples. The third round was later collected to confirm the results of C_{12} and C_{13} ratios detected during the first round. Results were similar.

The ISGS provided Dames & Moore with a draft report on June 12, 1992, and a final report on July 9, 1992. The ISGS final report concluded that the isotopic composition of methane samples taken from the intermediate and deep piezometers, which penetrate the lower lacustrine and glacial till sediments at the CWMCS Chicago Incinerator facility, indicate that the primary source of methane gas is from natural microbial reduction of CO_2 in the subsurface sediments.

Age dating and isotope analysis indicate that the methane in the upper lacustrine sediments (shallow zone) is probably a mixture of methane produced in the deeper zones by the CO₂ reduction pathway and microbial methane produced via the fermentation pathway in the shallow zone. The C₁₄ results as well as the chemical composition of the gas samples from wells nearest the adjacent landfill indicate that the methane formed via fermentation in the shallow zone is probably naturally occurring methane not related to landfill gas or other anthropogenic sources. The final ISGS report has been included as Appendix J.

3.0 SOURCE CHARACTERIZATION

This Source Characterization Evaluation for the nine (9) identified Hyon Solid Waste Management Units (SWMU) and the Hyon Tank Farm has been prepared with limited information. The SWMUs do not currently exist as a result of previous site restoration work. In addition, information is not available because access is restricted to Hyon records as a result of an ongoing lawsuit from the former operators of Hyon Waste Management and the City of Chicago. As indicated in the RFI Work Plan (6), the technical approach for this RFI is a "facility-wide" investigation, rather than an investigation of each separate waste management unit. This source characterization includes a limited discussion of the unit\disposal area characterization and type of waste in the unit. Physical and chemical characteristics, and migration and dispersal characteristics of the waste are not discussed.

A plan view of the site showing the location of the former SWMUs investigated as part of the RFI is included as Figure 3-1.

3.1 Biochemical Filterbeds (SWMU# 1)

3.1.1 Unit/Disposal Area Characteristics

The Biochemical Filterbeds were constructed by Hyon in the early 1970s and existed on the Northeast corner of the property directly North of the incinerator area. Waste quantities within this SWMU are unknown due to restricted access to Hyon records. Some quantities have been determined from documents obtained from CWMCS and information from 1975 aerial photographs (6). Based on the amount of material excavated from the Biochemical Filterbeds, it is estimated that this SWMU held approximately 30,000 cubic yards. (8).

The Biochemical Filterbeds consisted of two impoundments, each of which contained five (5) separate filterbeds.

Sludge was excavated from the Biochemical Filterbeds by SCA as part of the site restoration project in 1981-1982 and was placed in the clay lined vault located where the former SWMU #5 existed. The area where the Biochemical Filterbeds existed was then backfilled and graded.

3.1.2 Waste Characteristics

3.1.2.1 Type of Waste In Unit

Samples were collected from the Biochemical Filterbeds in November of 1980, prior to the site restoration and were analyzed to determine if they were hazardous under 40 CFR 261. The laboratory analysis report indicated that the material did not display characteristics of corrosivity, reactivity, ignitability, or EP toxicity to qualify for classification as hazardous waste (5).

Sample analysis results from the RFI Phase I report indicate elevated levels of metals concentrations in the level 1 and level 2 soils in the area where the Biochemical Filterbeds existed. Elevated levels of semi-volatiles and total volatiles in the level 1 soils (approximate base of the former SWMU) were also measured in samples collected for this investigation in the area where the Biochemical Filterbeds existed (7).

3.2 Activated Sludge Basins (SWMU# 2)

3.2.1 Unit/Disposal Area Characteristics

The Activated Sludge Basins were constructed by Hyon in the early 1970s and existed on the north side of the pier west of the Biochemical Filterbeds (SWMU #1), east of the interim status surface impoundments and north of the Drum Storage Area (SWMU #3).

Soil around the Activated Sludge Basins was analyzed, excavated and transported off-site for disposal in 1987 to prepare the area for installation of above ground storage tanks. The above

ground storage tanks were installed to replace the surface impoundments (Stabilization Basins) located west of the former Activated Sludge Basins (7).

3.2.2 Waste Characteristics

3.2.2.1 Type of Waste In Unit

Samples of material from the abandoned Activated Sludge Basin area were collected in 1987 and analyzed for hazardous characteristics and for EP Toxicity, in preparation for removal of the clarifier, sludge basin and surrounding soils. Test results indicated that the material tested was not classified as hazardous waste.

3.3 Drum Handling Area (SWMU# 3)

3.3.1 Unit/Disposal Area Characteristics

The Drum Handling Area was constructed by Hyon in the early 1970s and existed on the pier west of the Biochemical filterbeds (SWMU #1), east of the interim status surface impoundments and south of the Activated Sludge Basins (SWMU #2). The facility was equipped with a warehouse for the storage of containerized hazardous waste prior to transfer to bulk storage areas. The warehouse contained areas for drum storage, drum rinsing, and liquid transfer. The drum handling area was included in the closure plan for SCA Chemical Services, Inc., dated December 15, 1981 (10).

The closure plan called for the drums to be emptied and their contents transferred to bulk storage tanks. The plans indicated the drums would then be rinsed and the rinse water collected and tested for hazardous constituents. Hazardous rinse water was then to be processed on-site and non-hazardous rinse water was to be discharged to the municipal sewer system. Depending on the condition of the drums, they were then to be shipped to a drum reconditioner for reuse, or shipped to a secure landfill for disposal.

Decontamination of the warehouse area was to consist of rinsing the floors and walls with water after the drums were removed. The rinse water would be collected and tested for hazardous constituents. Hazardous rinse water was to be processed on-site and non-hazardous rinse water was to be discharged to the municipal sewer system.

Written documentation of this closure action is not available.

3.4 High Solids Area (SWMU# 4)

3.4.1 Unit/Disposal Area Characteristics

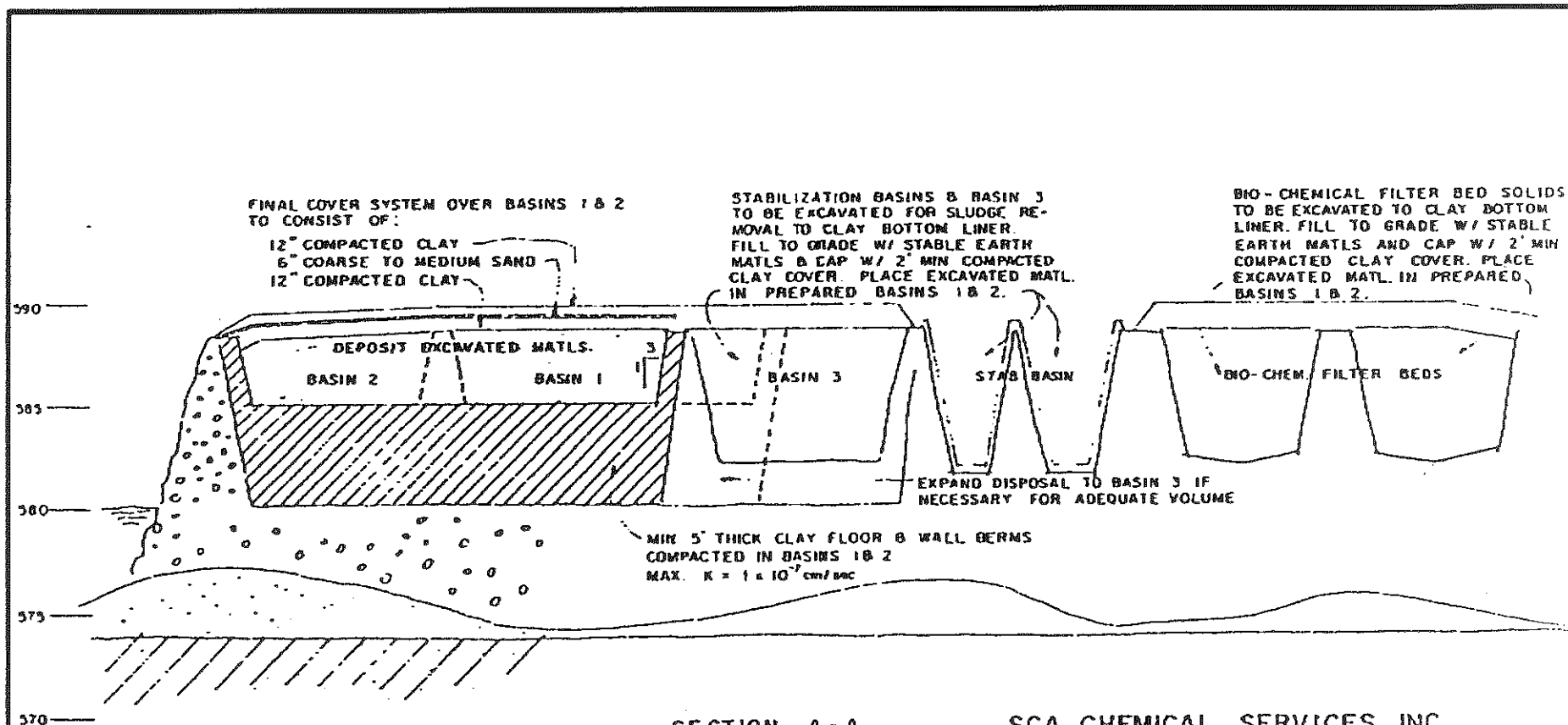
The High Solids Area (Basin #3) was constructed by Hyon in the early 1970s and existed on the pier west of the interim status surface impoundments and east of the Wastewater Basin #1 (SWMU #5). Waste quantities within this SWMU are unknown due to restricted access to Hyon records. Some quantities have been determined from documents obtained from CWMCS, information from 1975 aerial photographs (6), and a cross-section of the pier showing the depths of the former basins (See Figure 3-2). Based on the amount of material excavated from the High Solids Area, it is estimated that the basin was approximately seventeen (17) feet deep and held approximately 30,000 cubic yards (8).

Excavation of sludges from the High Solids Area, temporary on-site stockpiling, and replacement of sludges in the engineered, clay-lined vault located at the former SWMU #5 was performed in 1981-1982 as part of the site restoration project (6).

3.4.2 Waste Characteristics

3.4.2.1 Type of Waste In Unit

Samples were collected from the High Solids Area in November of 1980, prior to site restoration and were analyzed to determine if they were hazardous under 40 CFR 261. The laboratory



SECTION A-A
FINAL CONDITIONS

SCA CHEMICAL SERVICES, INC.
CHICAGO FACILITY SITE RESTORATION

SCALE 1" = 200' H. DRAWING NO. 1974-119H-4
 1" = 5' V.

FEB. 1, 1981



CWM CHEMICAL SERVICES INC.
CHICAGO INCINERATOR

FIGURE 3-2
SCHEMATIC DIAGRAM OF PIER CROSS SECTION
AT TIME OF PIER RESTORATION

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analysis report indicated that the material did not display characteristics of corrosivity, reactivity, ignitability, or EP toxicity to qualify for classification as hazardous waste (5). Sample analysis results from the RFI Phase I report indicate elevated levels of total volatiles in the level 1 soils in the area where the High Solids Area existed (7).

3.5 Wastewater Basin # 1 (SWMU# 5)

3.5.1 Unit/Disposal Area Characteristics

Wastewater Basin #1 was constructed by Hyon in the early 1970s and existed on the west end of the pier, west of the High Solids Area (SWMU #4) and east of Wastewater Basin #2 (SWMU #6). Waste quantities within this SWMU are unknown due to restricted access to Hyon records. Some quantities have been determined from documents obtained from CWMCS and information from 1975 aerial photographs (6). It is estimated that Wastewater Basin # 1 was approximately seventeen (17) feet deep and held approximately 5.8 million gallons (8).

Excavation of sludges from Wastewater Basin # 1, temporary on-site stockpiling, and replacement of sludges in the engineered, clay-lined vault located at the former SWMU #5 was performed in 1981-1982, as part of the site restoration project (6).

3.5.2 Waste Characteristics

3.5.2.1 Type of Waste In Unit

Samples were collected from Wastewater Basin #1 in November of 1980, prior to site restoration and were analyzed to determine if they were hazardous under 40 CFR 261. The laboratory analysis report indicated that the material did not display characteristics of corrosivity, reactivity, ignitability, or EP toxicity to qualify for classification as hazardous waste (5).

3.6 Wastewater Basin # 2 (SWMU# 6)

3.6.1 Unit/Disposal Area Characteristics

Wastewater Basin #2 was constructed in the early 1970s and existed at the west end of the pier, west of Wastewater Basin #1 (SWMU #4), immediately west of where the engineered, clay-lined vault now exists. Waste quantities within this SWMU are unknown due to restricted access to Hyon records. Some quantities have been determined from documents obtained from CWMCS and information from 1975 aerial photographs (6). It is estimated that Wastewater Basin #2 was approximately seventeen (17) feet deep and held approximately 5.8 million gallons (8).

Excavation of sludges from Wastewater Basin #2, and placement of sludges in the engineered, clay-lined vault located at the former SWMU #5 was performed in 1981-1982 as part of the site restoration project (6).

3.6.2 Waste Characteristics

3.6.2.1 Type of Waste In Unit

Samples were collected from Wastewater Basin #2 in November of 1980, prior to the site restoration and were analyzed to determine if they were hazardous under 40 CFR 261. The laboratory analysis report indicated that the material did not display characteristics of corrosivity, reactivity, ignitability, or EP toxicity to qualify for classification as hazardous waste (5).

Sample analysis results from the RFI Phase I report indicate elevated levels of metals concentrations in the level 1 (approximate base of the former SWMU) and level 2 (base of the fill) soils in the area where the Wastewater Basin #2 existed. Elevated levels of semi-volatiles and total volatiles in the level 1 soils were also indicated in the area where Wastewater Basin #2 existed (7).

3.7 Chemical Treatment Area (SWMU# 7)

3.7.1 Unit/Disposal Area Characteristics

The Chemical Treatment Area was constructed by Hyon in the early 1970s and was located on the east end of the property to the south of the former Biochemical Filterbeds (SWMU #1) location. Written documentation regarding the closure of this solid waste management unit is not available.

3.8 Biochemical Treatment Area (SWMU# 8)

3.8.1 Unit/Disposal Area Characteristics

The Biochemical Treatment Area was constructed by Hyon in the early 1970s and was located on the east end of the property to the south of the former Biochemical Filterbed (SWMU #1), north of the Tank Farm, and west of the Chemical Treatment Area (SWMU #7). Written documentation regarding the closure of this solid waste management unit is not available.

3.9 Process Water Underground Pipe System (SWMU# 9)

3.9.1 Unit/Disposal Area Characteristics

The Process Water Underground Pipe System consists of an underground pipeline constructed by Hyon in the early 1970s to transport incinerator scrubber water between the interim status surface impoundments and the incinerator. The pipeline originates at the incinerator and proceeds west between the former location of the Biochemical Filterbeds (SWMU #1) and the Biochemical Treatment Area (SWMU #8), and then north between the interim status surface impoundments and the Activated Sludge Basins (SWMU #2) to the northeast corner of the interim status surface impoundments.

A break in an elbow of the pipe near the northeast process pond in 1984 caused a spill of scrubber water (6). A section of the pipe was removed and the open ends of the pipe were filled with concrete as indicated by the drawing note dated February 16, 1988 on As-Built Drawing #1478-H-72, titled "Chicago Incinerator, Firewater, Cooling Water, and City Water, Underground Piping Plan, Basin Area" (6).

3.10 Tank Farm

3.10.1 Unit/Disposal Area Characteristics

The Tank Farm was constructed by Hyon in the early 1970s and was located at the southeast end of the property, south of the Biochemical Treatment Area (SWMU #8).

The Tank Farm was included in the closure plan for SCA Chemical Services, Inc., dated December 15, 1981 (10). The tanks contained flammable liquids which were to be processed on-site by incineration. After the storage/blend and feed tanks were emptied, the tanks and instrumentation were to be steam cleaned. Pumps, valves, and pipes were to be flushed with water and the area inside the containment dike was to be rinsed with water. Rinse solutions were to be tested for hazardous constituents. Rinse solutions that were hazardous were to be shipped off-site for disposal, and rinse solutions that were non-hazardous and within permitted discharge levels were to be discharged to the municipal sewer system.

Written documentation regarding the closure of this solid waste management unit is not available.

3.10.2 Waste Characteristics

3.10.2.1 Type of Waste In Unit

Sample analysis results from the RFI Phase I report indicated that semi-volatiles detected in the groundwater were concentrated in the active area near the Hyon tank farm. The semi-volatile constituents detected in the groundwater were mainly phenolic compounds (7).

4.0 CONTAMINANT CHARACTERIZATION

4.1 Introduction

The RFI investigation consisted of two phases of investigation. The scope of work is described in the approved 1989 Work Plan. Field work for Phase I was performed in the fall of 1989. The scope of work for Phase II of the investigation was approved in August, 1991. Field work for Phase II was performed in the fall of 1991.

Two interim reports and a draft RFI report have been submitted to the USEPA on this project. This report summarizes previously reported information incorporating Agency comments received.

The entire facility was investigated during both phases of the investigation. Sample collection has been performed by matrix rather than by SMWUs. Specific information on former waste management practices is contained in Hyon records. Access to these records is restricted by the City of Chicago because of an ongoing lawsuit. It is known that the former TSD handled a variety of waste, but specific locations of the compounds are unknown. It is speculated that the same types of waste were handled at multiple SWMU locations. To assume that a single SWMU is the source of a compound across the site is misleading. Former SWMUs have been identified and the work has been done to define these areas.

Matrices investigated include groundwater in the uppermost water-bearing unit, soil samples of both the fill material and underlying clay, and sediment and surface water samples from Lake Calumet. Additionally, surface soil samples were collected as part of the risk assessment during Phase II of the investigation. Table 4-1 summarizes sample locations by SWMU and matrix.

TABLE 4-1
SUMMARY OF SAMPLE LOCATIONS
FOR EACH SWMU BY MATRIX

GROUNDWATER		CLAY		FILL		LAKE CALUMET SURFACE WATER/SEDIMENT		SURFACE SOILS
Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	
Biochemical Filter Beds (Biobeds) (SWMU #1)								
G-305 G-307(u) G-314 G-330 G-332 G-334(u)	G-305 G-307(u) G-314 G-330 G-332 G-334 FG-1 FG-2 FG-3 FG-4 FG-5 FG-6 FG-7 FG-8 FG-9 FG-10	P-322 P-323 B-341	C-2 C-3 C-4 C-6	B-308 B-312 (#2) B-313 B-315 B-331 (#9) B-333 B-339 (#7) B-340 (#8) B-341 (#7) G-305 G-307 G-314 G-330 G-332 G-334(u) P-332 P-323 P-329	FG-1 FG-2 FG-3 FG-4 FG-5 FG-6 FG-7 FG-8 FG-9 FG-10		S,SW-1 S,SW-2 S,SW-3 S,SW-4	SS-1 SS-2 SS-3 SS-4 SS-14 SS-15 SS-16 SS-17
DRUM STORAGE AREA (SWMU #3)								
		B-328		B-321 B-328 (#9)				
STABILIZATION BASINS								
G-1205 G-1215 G-123 G-1245	G-1205 G-1215 G-123 G-1245	B-304		B-304 B-338				
HIGH SOLIDS BASIN (SMWU #4)								
G-303 G-337	G-303 G-337 FG-17	P-319	C-7	B-310 B-311 B-320 B-326 G-303 G-337 P-319	FG-17			SS-5 SS-20 SS-21

**TABLE 4-1 - (Cont.)
SUMMARY OF SAMPLE LOCATIONS
FOR EACH SWMU BY MATRIX**

GROUNDWATER		CLAY		FILL		LAKE CALUMET SURFACE WATER/SEDIMENT		SURFACE SOILS
Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	
WASTEWATER BASIN #1 AND VAULT (SMWU #5)								
G-302 G-318 G-336 V-1	G-302 G-318 G-336 L-1 L-2 L-3 L-4			G-318 G-336			S,SW-6 SW-10	SS-6 SS-10 SS-22 SS-23
WASTEWATER BASIN #2 (SMWU #6)								
G-308 G-317 G-324	G-308 G-317 G-324 FG-15 FG-16	P-316	C-1	B-301 B-309 B-325 B-327 B-335 G-308 G-317 G-324 G-324A P-316	FG-15 FG-16		S,SW-7 S,SW-8 S,SW-9	SS-7 SS-8 SS-9 SS-18 SS-19
HYON TANK FARM								
G-342 G-343(u) G-344 G-347(u) G-348 G-349(u)	G-342 G-343(u) G-344 G-347(u) G-348 G-349(u) FG-11 FG-12 FG-13 FG-14	B-346	C-5	B-345 B-346 G-342 G-343(u) G-344 G-347(u) G-348 G-349(u)	FG-11 FG-12 FG-13 FG-14		S,SW-5	

**TABLE 4-1 - (Cont.)
SUMMARY OF SAMPLE LOCATIONS
FOR EACH SWMU BY MATRIX**

GROUNDWATER		CLAY		FILL		LAKE CALUMET SURFACE WATER/SEDIMENT		SURFACE SOILS
Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	
LAKE CALUMET								
						SW-1 S-15 SW-2 S-16 SW-3 S-17 SW-4 S-18 SW-5 S-19 S-1 S-20 S-2 S-21 S-3 S-22 S-4 S-23 S-5 S-24 S-6 S-25 S-7 S-26 S-8 S-27 S-9 S-28 S-10 S-29 S-11 S-30 S-12 S-13 S-14	SW-11 SW-12 SW-13 SW-14 SW-15	
UNDEVELOPED PIER								
								SS-11 SS-12 SS-13

- (u) - Upgradient well.
(#2) - Also includes SWMU #2.
(#7) - Also includes SWMU #7.
(#8) - Also includes SWMU #8.
(#9) - Also includes SWMU #9.

Samples were analyzed for volatiles, semi-volatiles, and metals, as outlined in the approved work plans for both phases of the investigation. Specific analytes for each category varied between matrix and phase of investigation. A description of the laboratory analysis for each matrix and phase is presented at the beginning of each section.

4.2 Groundwater Sample Results

Groundwater samples were collected during Phase I and Phase II of the investigation as outlined in the Work Plans. Phase I samples were collected from 24 RFI wells, 20 of which were installed in the fill material during Phase I (The fill unit is the uppermost water bearing unit). Boring logs for these wells have been included in Appendix A. Well construction forms are shown in Appendix C. A second round of samples was collected from the RFI wells during Phase II. Additional groundwater samples were collected from 17 locations with a Hydropunch II® sampling device. RFI well and hydropunch locations are shown on Figure 1-2. FG-1 through FG-10 are located in the biobeds area. FG-11 through FG-14 are located near the former Hyon tank farm. FG-15 and FG-16 are located in the former waste water basin on the west end of the pier. FG-17 is located in the former high solids basin. No sample was collected from FG-16 because of insufficient recharge. Analysis on volatiles only was performed on FG-11 and FG-17 for the same reason.

Phase I samples were analyzed for the full Appendix IX compound list. Phase II samples were restricted to metals, volatiles, and semi-volatiles in Appendix IX, as outlined in the Work Plan and Phase II Work Plan Addendum. Phase I analysis included pesticides, herbicides, dibenzofurans, and dioxins, which were omitted from the Phase II program. None of these (Phase I only) compounds were a major contributor to groundwater contamination. With Agency approval, these constituents were eliminated during Phase II. For this report, detected parameters were divided into metals, organic, and inorganic constituents. Inorganic constituents

are reported in mg/L. Metals and organic constituents are reported in $\mu\text{g/L}$. Organics were further divided into chemical groups. Laboratory reports have been included in Appendix K.

4.2.1 Inorganic Constituents

Inorganic constituents analyzed during Phase I are summarized in Table 4-2. With Agency approval none of these constituents were analyzed during Phase II. Field measurements taken during Phase I and Phase II are listed in Table 4-3. The following list of inorganic compounds and field parameters were analyzed:

**Calcium
Chloride
Cyanide, Total
Magnesium
Potassium
Sodium
Sulfate, SO_4
Sulfide
Specific Conductance (Field)
pH (Field)
Temperature (Field)**

Calcium (Ca)

Calcium concentrations ranged from 127 mg/L in sample G-343 to 3,990 mg/L in sample G-302. G-343 is a up gradient well along the east property boundary. Other upgradient well samples yielded a wide range of concentrations, from 1,350 mg/L in G-307, 1,050 mg/L in G-334, and 368 mg/L in G-347.

Chloride (Cl)

Chloride concentrations ranged from 23.8 mg/L in sample G-343 to 9,030 mg/L in sample G-121S. G-343 is an upgradient well. The other upgradient wells including G-307, G-334, and G-347 yielded chloride concentrations of 254 mg/L, 426 mg/L, and 212 mg/L respectively.

TABLE 4-2
GROUNDWATER PHASE I INORGANICS

	Ca	Cl	CN,tot	Mg	K	Na	SO ₄	S
G-302	3990	531	< 0.01	1560	104	208	194	< 0.25
G-303	89	492	< 0.01	153	71	231	54	1.30
G-305	384	-	< 0.01	129	22	93.9	-	< 0.25
G-307	1350	254	< 0.01	453	72.9	169	1130	2.30
G-308	911	417	< 0.01	400	119	292	185	17.30
G-314	1200	2432	< 0.01	218	160	442	221	2.00
G-317	1150	219	< 0.01	46.6	125	122	25.8	2.70
G-318	404	294	< 0.01	180	36	82.4	195	0.62
G-324	647	1124	0.374	190	176	606	510	16.10
G-330	179	371	< 0.01	70.7	29	236	260	4.70
G-332	910	700	< 0.01	177	120	265	25.5	11.30
G-334	1050	426	< 0.01	262	128	176	1400	1.60
G-336	688	593	< 0.01	467	153	286	340	5.70
G-337	434	476	< 0.01	155	50.1	139	552	1.00
G-342	1420	1752	< 0.01	74.8	156	1080	1850	2.80

All concentrations reported in mg/L.

**TABLE 4-2 (Cont.)
GROUNDWATER PHASE I INORGANICS**

	Ca	Cl	CN,tot	Mg	K	Na	SO ₄	S
G-343	127	23.8	< 0.01	44	16	22	243	< 0.25
G-344	491	1320	< 0.01	34.6	419	593	835	18.60
G-347	368	212	< 0.01	185	28	117	210	0.30
G-348	227	1024	< 0.01	123	439	346	154	2.30
G-349	524	549	< 0.01	58.3	278	352	390	0.40
G-120S	140	291	< 0.01	326	31	126	< 5.0	.62
G-121S	338	9030	< 0.01	163	-	5010	470	0.48
G-123S	387	2092	< 0.01	180	231	742	91.6	1.20
G-124S	515	1195	< 0.01	128	48	272	650	< 0.25

All concentrations reported in mg/L.

Cyanide, total (CN)

Total cyanide was detected in only one sample at a concentration of 0.374 mg/L, in G-324.

Magnesium (Mg)

Magnesium concentrations magnesium ranged from 44 mg/L in sample G-343 to 1,560 mg/L in sample G-302. G-343 and G-307 are upgradient wells. The other upgradient wells G-334 and G-347 yielded sample concentrations of magnesium at 262 mg/L and 185 mg/L respectively.

Potassium (K)

Concentrations of potassium ranged from 16 mg/L in a sample from G-343 to 439 mg/L in a sample from G-348. G-343 is an upgradient well. The other upgradient wells yielded sample concentrations of potassium at 72.9 mg/L, 128 mg/L, and 28 mg/L at G-307, G-334, and G-347 respectively.

Sodium (Na)

Concentrations of sodium ranged from 22 mg/L in a sample from G-343 to 5,010 mg/L in a sample from G-121S. G-343 is an upgradient well. The other upgradient wells yielded sample concentrations of sodium at 169 mg/L, 176 mg/L, and 117 mg/L at G-307, G-334, and G-347 respectively.

Sulfate, as SO₄

Concentrations of sulfate ranged from below a detection limit of 5.0 mg/L in a sample from G-120S to 1,850 mg/L in a sample from G-342. Upgradient wells yielded sample concentrations of sulfate at 1,400 mg/L, 243 mg/L, and 154 mg/L at G-334, G-343, and G-347 respectively.

Sulfide, as S

Concentrations of sulfide ranged from below a detection limit of 0.25 mg/L in a sample from G-124S, G-302, G-305, and G-343 to 18.6 mg/L in a sample from G-344. G-343 is an upgradient well. The other upgradient wells yielded sample concentrations of sulfide at 2.3 mg/L, 1.6 mg/L, and 0.30 mg/L at G-307, G-334, and G-347 respectively.

Specific Conductance

Specific conductance was measured in the field during both phases of the investigation at the time of sampling. Values range from 20,000 μ mhos/cm in the G-120S sample to 758 μ mhos/cm in the G-345 sample. 20,000 μ mhos/cm is the maximum value that the instrument will record.

pH

pH was measured in the field during both phases of the investigation at the time of sampling. pH values ranged from 6.84 in the G-120S sample collected during Phase II of the investigation to 13.01 in the G-317 sample collected during Phase I of the investigation.

Temperature

Temperature was measured in the field during both phases of the investigation at the time of sampling. Temperature of the groundwater ranged from 8.8 to 17.9 degrees Celsius. Most reported values for temperature range from 10 to 15 degrees Celsius.

TABLE 4-3
GROUNDWATER PHASE I AND PHASE II FIELD MEASUREMENTS

	Specific Conductance $\mu\text{mhos/cm}$	Temperature Deg. C	pH	Specific Conductance $\mu\text{mhos/cm}$	Temperature Deg. C	pH
	PHASE I			PHASE II		
G-302	2,940	12.9	12.26	2,088	12.0	10.51
G-303	2,620	13.7	8.02	794	13.4	7.68
G-305	2,420	10.9	7.22	3,048	12.9	7.33
G-307	2,800	14.5	7.65	2,005	8.8	9.23
G-308	2,290	12.0	9.51	1,493	12.1	9.97
G-314	7,670	12.9	7.06	7,720	8.8	7.0
G-317	9,110	13.6	13.01	9,438	12.2	12.89
G-318	1,760	11.7	7.46	2,370	13.0	7.68
G-324	4,630	12.5	11.77	2,455	11.7	11.68
G-330	1,700	13.6	9.10	1,735	13.3	8.55
G-332	4,240	10.4	12.34	6,830	9.9	12.84
G-334	3,360	13.3	8.61	3,825	11.9	8.56
G-336	3,130	10.5	8.50	3,538	13.0	7.77
G-337	2,790	13.6	7.17	3,098	12.6	7.48
G-342	7,310	15.1	9.50	5,975	8.10	9.41
G-343	758	13.7	7.78	879	11.70	7.43
G-344	5,520	15.0	10.07	4,548	11.60	9.53

TABLE 4-3 (Cont.)
GROUNDWATER PHASE I AND PHASE II FIELD MEASUREMENTS

	Specific Conductance $\mu\text{mhos/cm}$	Temperature Deg. C	pH	Specific Conductance $\mu\text{mhos/cm}$	Temperature Deg. C	pH
	PHASE I			PHASE II		
G-347	1,480	14.3	7.83	1,560	14.50	7.65
G-348	4,750	15.0	8.59	3,713	11.50	8.29
G-349	2,940	14.6	10.38	2,558	11.60	10.64
G-120S	3,280	13.4	6.94	2,958	14.4	6.84
G-121S	20,000	14.3	8.15	20,000*	13.70	7.73
G-123S	7,170	15.7	8.07	6,708	13.4	7.73
G-124S	4,050	17.9	7.13	4,543	14.30	7.19
FG-1				3,295	13.0	11.49
FG-2				4,910	12.7	9.61
FG-3				5,813	16.0	7.45
FG-4				3,875	15.9	11.35
FG-5				4,348	15.2	11.17
FG-6				14,200	18.3	12.59
FG-7				13,825	15.1	10.54
FG-8				2,980	14.0	9.71
FG-9				6,920	11.6	10.01
FG-10				5,400	-	8.16
FG-11				2,732	-	11.24

TABLE 4-3 (Cont.)
GROUNDWATER PHASE I AND PHASE II FIELD MEASUREMENTS

	Specific Conductance $\mu\text{mhos/cm}$	Temperature Deg. C	pH	Specific Conductance $\mu\text{mhos/cm}$	Temperature Deg. C	pH
	PHASE I			PHASE II		
FG-12				5,340	16.8	11.28
FG-13				1,887	9.2	8.85
FG-14				4,045	11.0	9.23
FG-15				10,200	11.7	12.98
FG-16				-	-	-
FG-17				-	-	-

Specific Conductance, pH and temperature measurements taken in field at time of sampling. Insufficient volume at FG-16 and FG-17, no field measurements taken. Field temperature at FG-10 and FG-11 not available.

* Maximum value instrument capable of recording.

4.1.2 Metals

Antimony	Mercury
Arsenic	Nickel
Barium	Selenium
Beryllium	Silver
Cadmium	Thallium
Chromium	Tin
Cobalt	Vanadium
Copper	Zinc
Lead	

Antimony

The maximum concentration of antimony was 120 μ g/L detected in the FG-3 sample during Phase II of the investigation. Antimony was also detected in the G-302 sample at a concentration of 99 μ g/L during Phase I of the investigation, but not detected at the location during Phase II. Results are listed in Tables 4-4 and 4-5.

Arsenic

The maximum concentration of arsenic was 1,600 μ g/L detected in the G-342 sample during Phase I of the investigation. Arsenic was detected in 19 RFI wells during Phase I, and five RFI wells and four Hydropunch II samples during Phase II. Phase II concentrations were all less than Phase I results. Results are listed in Tables 4-4 and 4-5.

Barium

The maximum concentration of barium was 2,860 μ g/L detected in the G-332 sample during Phase I of the investigation. Barium was detected in all groundwater samples for both phases of the investigation. Overall, Phase II results were lower than Phase I results. Results are listed in Tables 4-4 and 4-5.

**TABLE 4-4
GROUNDWATER PHASE I METALS**

	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Vanadium	Zinc
G120S	ND	55.0	980.0	ND	7.90	20.0	ND	17.0	24,500.0	30.0	ND	ND	ND	ND	ND	36.0	130.0
G121S	ND	19.0	140.0	ND	2.50	100.0	ND	ND	ND	9.30	ND	30.0	ND	ND	ND	21.0	23.0
G123S	ND	ND	1,500.0	ND	5.0	59.0	ND	35.0	15,200.0	110.0	0.24	56.0	ND	ND	ND	38.0	130.0
G124S	ND	ND	140.0	ND	7.30	150.0	ND	34.0	15,600.0	59.0	ND	51.0	ND	10.0	ND	35.0	140.0
G302	99.0	150.0	1,200.0	15.0	60.0	370.0	90.0	510.0	ND	2,400.0	0.33	270.0	ND	46.0	ND	340.0	2,000.0
G303	ND	15.0	570.0	ND	ND	31.0	22.0	50.0	ND	210.0	0.39	26.0	ND	ND	ND	33.0	410.0
G305	ND	16.0	130.0	ND	ND	30.0	24.0	46.0	ND	57.0	ND	31.0	ND	ND	ND	39.0	120.0
G307	ND	130.0	1,000.0	8.50	60.0	210.0	170.0	350.0	ND	820.0	0.43	270.0	ND	32.0	ND	340.0	1,200.0
G308	ND	170.0	1,500.0	8.90	56.0	220.0	110.0	590.0	ND	1,900.0	2.0	660.0	ND	23.0	ND	320.0	1,900.0
G314	ND	150.0	1,400.0	11.0	35.0	180.0	81.0	180.0	ND	620.0	0.52	150.0	9.20	16.0	ND	300.0	1,400.0
G317	ND	17.0	2,010.0	1.10	4.60	170.0	ND	200.0	ND	830.0	1.0	110.0	ND	ND	ND	170.0	1,000.0
G318	ND	78.0	510.0	3.70	10.0	140.0	91.0	160.0	ND	350.0	0.39	160.0	ND	ND	ND	160.0	390.0
G324	ND	ND	1,600.0	4.40	17.0	120.0	49.0	290.0	79,500.0	3,700.0	1.70	230.0	ND	11.0	ND	160.0	2,050.0
G330	ND	ND	220.0	2.70	11.0	78.0	27.0	88.0	53,400.0	210.0	0.37	67.0	ND	ND	ND	120.0	360.0
G332	ND	180.0	2,860.0	19.0	76.0	390.0	100.0	460.0	317,000.0	2,000.0	1.60	430.0	ND	21.0	ND	730.0	2,900.0
G334	ND	94.0	550.0	4.40	27.0	96.0	65.0	200.0	ND	590.0	0.79	130.0	ND	17.0	ND	180.0	860.0
G336	ND	68.0	720.0	4.90	38.0	110.0	47.0	520.0	ND	1,100.0	0.70	140.0	5.60	18.0	ND	190.0	1,300.0
G337	ND	56.0	570.0	4.10	11.0	150.0	96.0	240.0	ND	490.0	0.85	180.0	ND	ND	ND	180.0	600.0
G342	ND	1,600.0	460.0	35.0	70.0	490.0	51.0	280.0	167,000.0	360.0	0.55	190.0	ND	12.0	ND	1,300.0	3,050.0
G343	ND	ND	130.0	ND	ND	15.0	ND	22.0	ND	110.0	ND	ND	ND	ND	ND	27.0	95.0
G344	ND	130.0	370.0	12.0	18.0	190.0	31.0	100.0	ND	180.0	ND	130.0	19.0	ND	ND	360.0	1,100.0
G347	ND	30.0	330.0	1.90	11.0	47.0	30.0	86.0	ND	470.0	ND	52.0	ND	ND	ND	89.0	370.0
G348	ND	65.0	880.0	9.40	22.0	140.0	28.0	130.0	72,700.0	840.0	0.69	90.0	8.70	ND	ND	230.0	1,300.0
G349	ND	190.0	710.0	23.0	56.0	380.0	69.0	220.0	ND	270.0	0.20	210.0	29.0	ND	20.0	690.0	2,230.0

ND - Nondetect
All concentrations are in µg/l

TABLE 4-5
GROUNDWATER PHASE II METALS

	Antimony	Arsenic	Barium	Beryllium	Chromium	Cobalt	Copper	Lead	Mercury	Nickel	Selenium	Tin	Vanadium
FG-1GW	ND	ND	49.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
FG-2GW	ND	ND	92.00	ND	ND	ND	11.00	ND	ND	33.00	5.00	ND	ND
FG-3GW	120.00	620.00	970.00	ND	ND	ND	11.00	6.30	ND	220.00	12.00	89.00	ND
FG-4GW	ND	ND	79.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	26.00
FG-5GW	ND	46.00	77.00	ND	12.00	ND	ND	ND	ND	92.00	29.00	ND	200.00
FG-6GW	ND	ND	24.00	ND	12.00	ND	ND	ND	ND	200.00	13.00	ND	280.00
FG-7GW	ND	43.00	390.00	1.40	ND	ND	22.00	ND	ND	56.00	ND	60.00	27.00
FG-8GW	ND	43.00	92.00	ND	ND	ND	ND	ND	ND	55.00	ND	ND	32.00
FG-9GW	ND	ND	82.00	ND	ND	ND	ND	ND	ND	92.00	8.00	ND	ND
FG-10GW	ND	ND	270.00	ND	ND	ND	ND	ND	ND	110.00	ND	160.00	ND
FG-12GW	ND	ND	180.00	ND	ND	ND	ND	ND	ND	51.00	ND	ND	54.00
FG-13GW	ND	ND	64.00	ND	ND	ND	ND	ND	ND	43.00	ND	ND	ND
FG-14GW	ND	ND	93.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
FG-15GW	ND	ND	420.00	ND	ND	ND	ND	ND	ND	48.00	ND	ND	ND
G120S	ND	41.00	830.00	ND	ND	ND	ND	ND	ND	ND	ND	250.00	ND
G121S	ND	ND	410.00	ND	ND	ND	ND	ND	ND	29.00	ND	220.00	ND
G124S	ND	ND	65.00	ND	ND	ND	ND	ND	ND	ND	ND	81.00	ND
G302	ND	ND	74.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
G303	ND	ND	50.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE 4-5
GROUNDWATER PHASE II METALS

	Antimony	Arsenic	Barium	Beryllium	Chromium	Cobalt	Copper	Lead	Mercury	Nickel	Selenium	Tin	Vanadium
G305	ND	ND	54.00	ND	ND	26.00	ND	ND	ND	ND	ND	ND	ND
G307	ND	ND	25.00	ND	ND	ND	ND	ND	ND	ND	33.00	ND	ND
G308	ND	130.00	41.00	ND	ND	ND	ND	ND	ND	30.00	ND	ND	ND
G314	ND	97.00	520.00	ND	ND	ND	ND	ND	ND	39.00	ND	ND	ND
G317	ND	ND	1,700.00	ND	ND	ND	ND	ND	ND	31.00	ND	ND	ND
G318	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
G324	ND	ND	58.00	ND	ND	ND	ND	ND	0.30	ND	ND	ND	ND
G330	ND	ND	41.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
G332	ND	ND	610.00	ND	ND	ND	ND	ND	ND	47.00	ND	ND	ND
G334	ND	ND	47.00	ND	ND	ND	ND	ND	ND	ND	ND	52.00	ND
G336	ND	ND	86.00	ND	ND	ND	ND	ND	ND	ND	ND	190.00	ND
G337	ND	ND	70.00	ND	ND	ND	ND	ND	1.20	ND	ND	ND	ND
G342	ND	42.00	26.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	29.00
G343	ND	ND	58.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
G344	ND	27.00	58.00	ND	ND	ND	ND	ND	ND	31.00	ND	ND	ND
G347	ND	ND	180.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
G348	ND	ND	110.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
G349	ND	ND	91.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	29.00

ND - Nondetect
All concentrations are in µg/l

cwm/table.4-5

Beryllium

The maximum concentration of beryllium was 35 $\mu\text{g/L}$ detected in the G-332 sample during Phase I of the investigation. Beryllium was detected in 17 of the 24 RFI well locations during Phase I. No detections of beryllium were reported for any RFI wells during Phase II. The only detection of beryllium during Phase II was at a concentration of 1.4 $\mu\text{g/L}$ in the FG-7 sample. Results are listed in Tables 4-4 and 4-5.

Cadmium

The maximum concentration of cadmium was 76 $\mu\text{g/L}$ detected in the G-332 sample during Phase I of the investigation. Cadmium was detected at 21 of the 24 RFI wells during Phase I and not detected at any sample locations during Phase II. Results are listed in Tables 4-4 and 4-5.

Chromium

The maximum concentration of chromium was 490 $\mu\text{g/L}$ detected in the G-342 during Phase I of the investigation. Chromium was detected at all 24 RFI well locations during Phase I and at none of the locations during Phase II. Chromium was detected in the FG-5 and FG-6 samples, both at a concentration of 12 $\mu\text{g/L}$ during Phase II of the investigation. Results are listed in Tables 4-4 and 4-5.

Cobalt

The maximum concentration of cobalt was 170 $\mu\text{g/L}$ detected at the G-307 location during Phase I of the investigation. Cobalt was detected at 18 of the 24 RFI well locations during Phase I. During Phase II, the only detection of cobalt was at a concentration of 26 $\mu\text{g/L}$ in the G-305 sample. Results are listed in Tables 4-4 and 4-5.

Copper

The maximum concentration of copper was 590 $\mu\text{g/L}$ detected in the G-308 sample during Phase I of the investigation. Copper was detected at 23 of the 24 RFI locations during Phase I and at none during Phase II. During Phase II, copper was detected in the FG-2, FG-3 and FG-7 samples at concentrations of 11 $\mu\text{g/L}$, 11 $\mu\text{g/L}$ and 22 $\mu\text{g/L}$ respectively. Results are listed in Tables 4-4 and 4-5.

Iron

The maximum concentration of iron was 317,000 $\mu\text{g/L}$ detected in the sample collected from G-330 during Phase I of the investigation. Iron was detected in eight RFI well samples during Phase I. Iron was not analyzed during Phase II of the investigation. Results are listed in Table 4-4.

Lead

The maximum concentration of lead was 3,700 $\mu\text{g/L}$ detected in the G-324 sample during Phase I of the investigation. Lead was detected in all 24 RFI well locations during Phase I. The only detection of lead during Phase II was in the FG-3 sample at a concentration of 6.30 $\mu\text{g/L}$. Results are listed in Tables 4-4 and 4-5.

Mercury

The maximum concentration of mercury was 2.0 $\mu\text{g/L}$ detected in the G-308 sample during Phase I of the investigation. Mercury was detected in 17 of the 24 RFI well samples during Phase I and in 2 RFI well samples during Phase II. Results are listed in Tables 4-4 and 4-5.

Nickel

The maximum concentration of nickel was 660 $\mu\text{g/L}$ detected in the G-308 sample during Phase I of the investigation. Nickel was detected in 22 of the 24 RFI well samples during

Phase I and six of the 24 RFI well samples during Phase II. Nickel was also detected in 11 of the 15 Hydropunch II samples during Phase II. Results are listed in Tables 4-4 and 4-5.

Selenium

The maximum concentration of selenium was 33 $\mu\text{g/L}$ detected in the G-307 sample during Phase II of the investigation. Selenium was also detected in five RFI well samples during Phase I of the investigation, and one RFI well sample collected during Phase II of the investigation. Selenium was also detected in five Hydropunch groundwater samples collected during Phase II of the investigation. Results are listed in Tables 4-4 and 4-5.

Silver

The maximum concentration of silver was 46 $\mu\text{g/L}$ detected in the sample collected from G-302 during Phase I of the investigation. Silver was detected in 10 RFI wells during Phase I of the investigation, and not detected at any sample locations during Phase II. Results are listed in Table 4-4.

Thallium

The maximum concentration of thallium was 20 $\mu\text{g/L}$ detected in the sample collected from G-349 during Phase I of the investigation. This was the only detection of thallium in groundwater during both phases of the investigation. Results are listed in Table 4-4.

Tin

The maximum concentration of tin was 250 $\mu\text{g/L}$ detected in the G-120S sample during Phase II of the investigation. Tin was detected in five of the 24 RFI well samples and three Hydropunch II samples during Phase II of the investigation. Tin was not detected in any of the RFI groundwater samples collected during Phase I. Results are listed in Tables 4-4 and 4-5.

Vanadium

The maximum concentration of vanadium was 1,300 $\mu\text{g/L}$ detected in the G-342 sample during Phase I of the investigation. Vanadium was detected in all 24 RFI well samples during Phase I of the investigation. Vanadium was detected in two of the 24 RFI well samples and six Hydropunch II samples during Phase II of the investigation. Results are listed in Tables 4-4 and 4-5.

Zinc

The maximum concentration of zinc was 3,050 $\mu\text{g/L}$ detected in the G-342 sample during Phase I of the investigation. Zinc was not detected in any groundwater samples collected during Phase II of the investigation. Results are listed in Table 4-4.

4.2.3 Organic Constituents

As described earlier, the Phase I groundwater program consisted of analysis for the full suite of Appendix IX compounds. Organic compounds eliminated from Phase II included PCBs, pesticides, herbicides, dibenzofurans and dioxins. The Phase II program received Agency approval since minimal detects of these organic compounds were measured during Phase I. The majority of organic compound detects included volatile and semi-volatile compounds. To evaluate this data, organic chemical constituents are grouped into nine chemical groups. The nine chemical groups include: 1.) Aromatics; 2.) Halogenated Aromatics; 3.) Halogenated Hydrocarbons (chlorinated hydrocarbons); 4.) Ketones; 5.) Nitrogen Aromatics; 6.) Nitrogen Hydrocarbons; 7.) Phenols; 8.) Polyaromatic Hydrocarbons (PAHs); and 9.) Miscellaneous organics. Table 4-6 summarizes organic constituents by group. Miscellaneous organics include those constituents with few detections, and cannot be included in any other group. Pesticides detected in Phase I samples are included in this group.

TABLE 4-6
SUMMARY OF ORGANIC CONSTITUENTS
DETECTED IN GROUNDWATER BY CHEMICAL GROUP

Aromatic Hydrocarbons	Halogenated Hydrocarbons (Chlorinated Hydrocarbons)	Phenols	Polyaromatic Hydrocarbons	Miscellaneous Hydrocarbons
Benzene	1,1,1-Trichloroethane	2,3,4,6-Tetrachlorophenol	2-Methylnaphthalene	1,4-Dioxane
Benzyl Alcohol	1,1,2-Trichloroethane	2,4,5-Trichlorophenol	Acenaphthene	Acrolein
Ethylbenzene	1,1-Dichloroethane	2,4,6-Trichlorophenol	Anthracene	Bis-(2-Ethyhexyl)-phthalate
Pyridine	1,1-Dichloroethylene	2,4-Dichlorophenol	Benzo (a) pyrene	Carbon disulfide
Styrene	Chloroform	2,4-Dimethylphenol	Benzo (b) fluoranthene	Di-n-butyl-phthalate
Toluene	Dichlorofluoromethane	2,6-Dichlorophenol	Benzo (ghi) perylene	Isobutyl alcohol
m-xylene	Methylene Chloride	2-Chlorophenol	Chrysene	Phorate
o + p-xylene	Tetrachloroethylene	2-Nitrophenol	Fluoranthene	
	Trichloroethylene	Pentachlorophenol	Fluorene	
	Vinyl Chloride	Phenol	Indeno (1,2,3-c,d) pyrene	
		m + p Cresols	Naphthalene	
		o-Cresols	Phenanthrene	
		p-Chloro-m-cresol	Pyrene	

Halogenated Aromatics	Ketones	Nitrogen Aromatics	Nitrogen Hydrocarbons
1,2-Dichlorobenzene	Acetone	Aniline	Acetonitrile
1,3-Dichlorobenzene	Acetophenone	o-Toluidine	Ethyl Cyanide
1,4-Dichlorobenzene	Methyl-ethyl-Ketone	p-Chloroaniline	
Chlorobenzene	Methyl-iso-butyl-Ketone	Nitrobenzene	
Hexachlorobenzene			

The maximum concentration of each constituent has been identified, in accordance with the Consent Judgement. Detected concentrations of all groundwater samples has been tabulated. Constituents for each of the nine groups are listed in the following discussion. Phase I and II results from the RFI wells are listed in the second and third columns. Groundwater samples collected with the Hydropunch II are listed in the third and fourth columns. ND refers to nondetectable concentrations.

4.2.3.1 Aromatic Hydrocarbons

Aromatic hydrocarbons detected in groundwater samples consist of the following:

- Benzene**
- Benzyl Alcohol**
- Ethylbenzene**
- Pyridine**
- Styrene**
- Toluene**
- m - Xylene**
- o+p - Xylene**

Benzene

The maximum concentration of benzene was 20,900 $\mu\text{g/L}$. This was detected in a sample from G-332 during Phase I of the investigation. Benzene was also detected in a sample from G-332 during Phase II at a concentration of 428 $\mu\text{g/L}$. Benzene is the most frequently occurring aromatic hydrocarbon detected in the groundwater. Concentrations of benzene detected in the groundwater are listed in the following table.

Benzene Concentrations ($\mu\text{g/L}$)

	RFI Wells		Hydropunch II	
	Phase I	Phase II		Phase II
G-121S	245	8	FG-2	1
G-123S	257	ND	FG-4	10
G-302	80	41	FG-5	4,260
G-308	12	62	FG-7	2,430
G-314	596	1,050	FG-12	122
G-317	31	24	FG-13	115
G-324	72	18	FG-14	14,200
G-330	ND	38	FG-15	482
G-332	20,900	428		
G-336	111	69		
G-342	ND	30		
G-344	212	137		
G-348	ND	119		
G-349	41	132		

Benzyl Alcohol

Benzyl alcohol was detected at a concentration of 21 $\mu\text{g/L}$ in a sample from FG-4. The Method Detection Limit was 13 $\mu\text{g/L}$. This was the only detection of benzyl alcohol in the groundwater samples during both phases of the investigation.

Ethylbenzene

The maximum concentration of ethylbenzene was 13,400 $\mu\text{g/L}$ detected in the FG-14 sample during Phase II of the investigation. Concentrations of ethylbenzene detected in the groundwater are listed below.

Ethylbenzene Concentrations ($\mu\text{g/L}$)

	RFI Wells		Hydropunch II	
	Phase I	Phase II		Phase II
G-121S	13	15	FG-12	134
G-344	90	ND	FG-13	158
G-348	ND	42	FG-14	13,400
G-349	67	800		

Pyridine

The maximum concentration of pyridine was 9,300 $\mu\text{g/L}$ detected in the FG-7 sample during Phase II of the investigation. Concentrations of pyridine detected in the groundwater are listed below.

Pyridine Concentrations ($\mu\text{g/L}$)

RFI Wells			Hydropunch II	
Phase I		Phase II	Phase II	
G-314	35	ND	FG-1	365
G-330	21.5	ND	FG-3	713
G-332	92	ND	FG-5	3,470
			FG-7	9,300
			FG-8	49.9
			FG-9	8,450

Styrene

The maximum concentration of styrene was 4,180 µg/L. This was detected in the FG-14 sample during Phase II of the investigation. Styrene was also detected in the G-349 samples at concentrations of 239 µg/L during Phase I and 1,980 µg/L during Phase II.

Toluene

The maximum concentration of toluene was 85,200 µg/L detected in the FG-14 sample during Phase II of the investigation. Toluene was the second most frequently occurring aromatic hydrocarbon. Concentrations of toluene detected in groundwater samples are listed below.

Toluene Concentrations (µg/L)

	RFI Wells		Hydropunch II	
	Phase I	Phase II		Phase II
G-121S	7	8	FG-5	5,570
G-123S	80	ND	FG-12	479
G-302	39	ND	FG-13	1,470
G-308	ND	28	FG-14	85,200
G-317	ND	12	FG-15	2,820
G-324	25	7		
G-330	ND	39		
G-332	14,700	385		
G-344	418	288		
G-348	ND	108		
G-349	353	1,500		

m - Xylene

The maximum concentration of m-Xylene was 6,480 µg/L detected in the FG-14 sample during Phase II of the investigation. Concentrations of m-Xylene detected in the groundwater are listed below.

m-Xylene Concentrations (µg/L)

	RFI Wells		Hydropunch II	
	Phase I	Phase II		Phase II
G-344	219	141	FG-12	341
G-348	ND	98	FG-13	338
G-349	205	1,260	FG-14	6,480

o+p - Xylenes

The maximum concentration of o+p - Xylenes was 5,060 µg/L detected in the FG-14 sample during Phase II of the investigation. Concentrations of o+p - Xylene detected in the groundwater are listed below.

o+p - Xylene Concentrations (µg/L)

	RFI Wells		Hydropunch II	
	Phase I	Phase II		Phase II
G-121S	12	11	FG-12	402
G-330	ND	12	FG-13	234
G-344	179	130	FG-14	5,060
G-348	ND	78		
G-349	ND	1,090		

4.2.3.2 Halogenated Aromatics

Halogenated aromatics detected in groundwater include the following:

1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
Chlorobenzene
Hexachlorobenzene

1,2-Dichlorobenzene

The maximum concentration of 1,2-Dichlorobenzene was 4,970 $\mu\text{g/L}$ detected in the FG-14 sample collected during Phase II of the investigation. Concentrations of 1,2-Dichlorobenzene detected in the groundwater are listed below.

1,2-Dichlorobenzene Concentrations ($\mu\text{g/L}$)

	RFI Wells		Hydropunch II	
	Phase I	Phase II		Phase II
G-121S	7	5	FG-13	6
G-348	ND	3	FG-14	4,970
			FG-15	7

1,3-Dichlorobenzene

1,3-Dichlorobenzene was detected at a concentration of 432 $\mu\text{g/L}$ in the FG-14 sample during Phase II of the investigation. This was the only detection of 1,3-Dichlorobenzene in groundwater samples during both phases of the investigation.

1,4-Dichlorobenzene

1,4-Dichlorobenzene was detected at a concentration of 559 $\mu\text{g/L}$ in the FG-14 sample during Phase II of the investigation. This was the only detection of 1,4-Dichlorobenzene in groundwater samples during both phases of the investigation.

Chlorobenzene

The maximum concentration of chlorobenzene was 963 $\mu\text{g/L}$ detected in the FG-5 sample during Phase II of the investigation. Concentrations of chlorobenzene detected in the groundwater are listed below.

Chlorobenzene Concentrations ($\mu\text{g/L}$)

	RFI Wells		Hydropunch II	
	Phase I	Phase II		Phase II
G-121S	58	65	FG-5	963
G-302	26	15	FG-12	21
G-317	ND	7	FG-14	701
G-324	16	27		
G-332	ND	63		
G-336	12	8		

Hexachlorobenzene

Hexachlorobenzene was detected at a concentration of 10 $\mu\text{g/L}$ in the FG-15 sample. This was the only detection of hexachlorobenzene in groundwater samples during both phases of the investigation.

4.2.3.3 Halogenated Hydrocarbons (Chlorinated Hydrocarbons)

The halogenated hydrocarbon compounds detected in the groundwater samples include the following:

- 1,1,1-Trichloroethane
- 1,1,2-Trichloroethane
- 1,1-Dichloroethane
- 1,1-Dichloroethylene
- 1,2-Dichloroethane
- 1,2-Trans-dichloroethylene
- Chloroform
- Dichlorofluoromethane
- Methylene Chloride
- Tetrachloroethylene
- Trichloroethylene
- Vinyl Chloride

1,1,1-Trichloroethane

The maximum concentration of 1,1,1-trichloroethane was 67,400 $\mu\text{g/L}$ detected in the FG-14 sample during Phase II of the investigation. 1,1,1-trichloroethane was also detected in the groundwater at a concentration of 18 $\mu\text{g/L}$ in the sample from G-348 during Phase II. No detectable concentrations were reported for Phase I.

1,1,2-Trichloroethane

The maximum concentration of 1,1,2-trichloroethane was 134,000 $\mu\text{g/L}$ detected in the FG-9 sample detected during Phase II of the investigation. Concentrations of 1,1,2-trichloroethane detected in the groundwater are listed in the following table.

1,1,2-Trichloroethane Concentrations ($\mu\text{g/L}$)

	RFI Wells		Hydropunch II	
	Phase I	Phase II		Phase II
G-123S	713	ND	FG-5	1,800
G-305	ND	6	FG-9	134,000
G-348	ND	41	FG-14	28,600

1,1-Dichloroethane

The maximum concentration of 1,1-dichloroethane was 3,560 $\mu\text{g/L}$ detected in the FG-14 sample during Phase II of the investigation. Concentrations of 1,1-dichloroethane detected in the groundwater are listed below.

1,1-Dichloroethane Concentrations ($\mu\text{g/L}$)

	RFI Wells		Hydropunch II	
	Phase I	Phase II		Phase II
G-308	5	8	FG-1	273
G-324	15	ND	FG-3	13
G-330	ND	11	FG-14	3,560
G-349	31	ND		

1,1-Dichloroethylene

The maximum concentration of 1,1-dichloroethylene was 358,000 $\mu\text{g/L}$ detected in the sample from G-332 during Phase I of the investigation. Concentrations of 1,1-dichloroethylene detected in the groundwater are listed in the following table.

1,1-Dichloroethylene Concentrations ($\mu\text{g/L}$)

	RFI Wells		Hydropunch II	
	Phase I	Phase II		Phase II
G-123S	4,730	ND	FG-1	2450
G-314	3,340	3,500	FG-2	56
G-317	33	35	FG-4	46
G-330	539	237	FG-5	52,300
G-332	358,000	2,240	FG-7	75,300
G-342	35	37	FG-9	46,900
G-344	28	ND	FG-13	98
G-348	ND	43	FG-14	39,800
			FG-15	2,430

1,2-Dichloroethane

The maximum concentration of 1,2-dichloroethane was detected in the FG-14 sample at a concentration of 6,250 $\mu\text{g/L}$ collected during Phase II of the investigation. Concentrations of 1,2-dichloroethane detected in the groundwater are listed below.

1,2-Dichloroethane Concentrations ($\mu\text{g/L}$)

	RFI Wells		Hydropunch II	
	Phase I	Phase II		Phase II
G-308	7.90	9.79	FG-12	58
G-324	47.70	ND	FG-14	6,250
G-344	80.50	ND		
G-348	ND	66.20		
G-349	19.40	ND		

1,2 trans-Dichloroethylene

The maximum concentration of 1,2-trans-dichloroethylene was 251 $\mu\text{g/L}$ detected in the FG-14 sample during Phase II of the investigation. Concentrations of 1,2-trans-dichloroethylene detected in the groundwater are listed below.

1,2 trans-Dichloroethylene Concentrations ($\mu\text{g/L}$)

	RFI Wells		Hydropunch II	
	Phase I	Phase II		Phase II
G-330	53	62	FG-4	13
G-349	16	ND	FG-5	218
			FG-14	251

Chloroform

Chloroform was detected at a concentration of 448 $\mu\text{g/L}$ in the FG-14 sample during Phase II of the investigation. This was the only detection of chloroform in groundwater.

Dichlorofluoromethane

The maximum concentration of dichlorofluoromethane was 555.0 $\mu\text{g/L}$ in the G-120S sample. The G-303 sample also detected dichlorofluoromethane at a concentration of 526.0 $\mu\text{g/L}$. Both detections occurred during Phase I of the investigation. No detections of dichlorofluoromethane were reported during Phase II of the investigation. Dichlorofluoromethane is a common lab artifact.

Methylene Chloride

The maximum concentration of methylene chloride was 651,000 $\mu\text{g/L}$ detected at FG-7 during Phase II of the investigation. Methylene chloride was detected in each sample collected from the RFI wells during Phase I. Phase II results detected methylene chloride in only four RFI well samples and in ten Hydropunch samples. This constituent was the most frequently occurring in the halogenated hydrocarbon group. This is most likely due to the fact that methylene chloride is a common lab artifact. Concentrations of methylene chloride detected in the groundwater samples are listed below.

Methylene Chloride Concentrations ($\mu\text{g/L}$)

	RFI Wells		Hydropunch II	
	Phase I	Phase II		Phase II
G-120S	3.87	ND	FG-1	1,280
G-121S	12	ND	FG-2	248
G-123S	7,300	ND	FG-5	15,000
G-124S	6	ND	FG-7	651,000
G-302	10	ND	FG-8	1,480
G-303	8	ND	FG-9	199,000
G-305	7	15	FG-11	478
G-307	6	ND	FG-12	27
G-308	50	10	FG-14	8,360
G-314	1,310	ND	FG-15	764
G-317	97	33		
G-318	8	ND		
G-324	44	ND		

	RFI Wells		Hydropunch II	
	Phase I	Phase II		Phase II
G-330	83	ND		
G-332	67,100	1,870		
G-334	23	ND		
G-336	18	ND		
G-337	18	ND		
G-342	155	ND		
G-343	7	ND		
G-344	61	ND		
G-348	481	ND		
G-349	41	ND		

Tetrachloroethylene

The maximum concentration of tetrachloroethylene was 2,650 $\mu\text{g/L}$ detected in the FG-14 sample collected during Phase II of the investigation. Tetrachloroethylene was also detected in the groundwater samples from G-349 at 128 $\mu\text{g/L}$ during Phase I and at 326 $\mu\text{g/L}$ during Phase II. No other detectable concentrations of tetrachloroethylene were reported.

Trichloroethylene

The maximum concentration of trichloroethylene was 2,220 $\mu\text{g/L}$ detected at FG-14 during Phase II of the investigation. Concentrations of trichloroethylene detected in groundwater samples are listed in the following table.

Trichloroethylene Concentrations ($\mu\text{g/L}$)

RFI Wells			Hydropunch II	
	Phase I	Phase II		Phase II
G-330	71	7	FG-4	3
G-349	18	ND	FG-5	284
			FG-14	2,200

Vinyl Chloride

The maximum concentration of vinyl chloride was 271,000 $\mu\text{g/L}$ detected in the sample from G-332 during Phase I of the investigation. Concentrations of vinyl chloride detected in groundwater samples are listed below.

Vinyl Chloride Concentrations ($\mu\text{g/L}$)

RFI Wells			Hydropunch II	
	Phase I	Phase II		Phase II
G-123S	6,500	ND	FG-1	445
G-308	28	ND	FG-2	26
G-314	14,500	2,250	FG-4	22
G-324	47	ND	FG-5	1,410
G-330	1,100	ND	FG-7	6,050
G-332	271,000	441		
G-348	954	33		

4.2.3.4 Ketones

Ketone compounds detected in the groundwater sample include the following:

Acetone
Acetophenone
Methyl-ethyl Ketone
Methyl-iso-butyl Ketone

Acetone

The maximum concentration of acetone was 80,700 $\mu\text{g/L}$ detected in the sample from FG-6 collected during Phase II of the investigation. Acetone was detected in 17 RFI well samples during Phase I. During Phase II, acetone was detected in 4 RFI well samples and 7 Hydropunch samples. This constituent was the most frequently occurring in the ketone group. This is most likely due to the fact that acetone is a common lab artifact. Concentrations of acetone detected in groundwater samples are listed below.

Acetone Concentrations ($\mu\text{g/L}$)

RFI Wells			Hydropunch II	
	Phase I	Phase II		Phase II
G-120S	10.40	ND	FG-1	1,500
G-123S	1,420	ND	FG-2	91
G-124S	20.10	ND	FG-4	49.90
G-302	47.10	ND	FG-6	80,700
G-303	14.30	ND	FG-7	16,100
G-305	13.30	ND	FG-10	18.40
G-308	88.40	ND	FG-12	499
G-317	675	398		
G-318	10.20	ND		

Acetone Concentrations ($\mu\text{g/L}$) - Cont.

RFI Wells			Hydropunch II	
	Phase I	Phase II		Phase II
G-332	ND	883		
G-337	53.60	ND		
G-342	875	607		
G-343	20.30	ND		
G-344	1,100	398		
G-347	23.70	ND		
G-348	586	ND		
G-349	376	ND		

Acetophenone

The maximum concentration of acetophenone was 12.6 $\mu\text{g/L}$ in the G-317 sample detected during Phase II of the investigation. Concentrations of acetophenone detected in groundwater samples are listed below.

Acetophenone Concentrations ($\mu\text{g/L}$)

RFI Wells			Hydropunch II	
	Phase I	Phase II		Phase II
G-317	ND	12.6	FG-15	11.8
G-344	11.5	ND		

Methyl-ethyl Ketone

The maximum concentration of methyl-ethyl ketone was 402 $\mu\text{g/L}$ detected in the sample from G-123S collected during Phase I of the investigation. Methyl-ethyl ketone was not detected in

any hydropunch samples. Concentrations of methyl-ethyl ketone detected in groundwater samples are listed below.

Methyl-ethyl Ketone Concentrations ($\mu\text{g/L}$)

RFI Wells		
	Phase I	Phase II
G-123S	402	ND
G-308	19	ND
G-317	ND	45
G-342	144	ND

Methyl-iso-butyl Ketone

The maximum concentration of methyl-iso-butyl ketone was 5,380 $\mu\text{g/L}$ detected in the FG-11 sample collected during Phase II of the investigation. Concentrations of methyl-iso-butyl ketone detected in groundwater samples are listed below.

Methyl-iso-butyl Ketone Concentrations ($\mu\text{g/L}$)

RFI Wells			Hydropunch II	
	Phase I	Phase II		Phase II
G-123S	221	ND	FG-5	1,460
G-308	19	ND	FG-11	5,380
G-330	ND	14	FG-12	582
G-342	425	861	FG-13	3,640
G-344	2,310	1,150		
G-348	2,300	171		
G-349	171	337		

4.2.3.5 Nitrogen Aromatics

The following nitrogen aromatics were detected in groundwater samples:

Aniline
o-Toluidine
p-Chloroaniline
Nitrobenzene

Aniline

The maximum concentration of aniline was 5,190 mg/L detected in the FG-14 sample during the Phase II investigation. Concentrations of aniline detected in groundwater samples are listed below.

Aniline Concentrations ($\mu\text{g/L}$)

RFI Wells			Hydropunch II	
	Phase I	Phase II		Phase II
G-308	ND	46.7	FG-1	194
G-344	1,070	706	FG-8	78.30
G-348	3,250	2,960	FG-9	5,190
			FG-12	418
			FG-13	2,850
			FG-14	5,190

o-Toluidine

The maximum concentration of o-toluidine was 283 $\mu\text{g/L}$ detected in the G-348 sample during Phase I of the investigation. Concentrations of o-toluidine detected in groundwater samples are listed on the following table.

o-Toluidine Concentrations ($\mu\text{g/L}$)

RFI Wells			Hydropunch II	
	Phase I	Phase II	Phase II	
G-344	232	ND	FG-8	33.1
G-348	283	ND		

p-Chloroaniline

The maximum concentration of p-chloroaniline was 429,000 $\mu\text{g/L}$ detected in the FG-14 sample collected during Phase II of the investigation. Concentrations of p-chloroaniline detected in groundwater samples are listed in the following table.

p-Chloroaniline Concentrations ($\mu\text{g/L}$)

RFI Wells			Hydropunch II	
	Phase I	Phase II		Phase II
G-121S	110	69	FG-1	103
G-308	25	617	FG-5	533
G-332	ND	12	FG-8	21
G-344	5,570	4,120	FG-9	13,900
G-348	6,350	6,860	FG-12	1,800
G-349	ND	40	FG-13	13,500
			FG-14	429,000

Nitrobenzene

The maximum concentration of nitrobenzene was 7,983 $\mu\text{g/L}$ detected in the FG-14 sample during Phase II of the investigation. Nitrobenzene was not detected in any groundwater samples from the RFI wells. Concentrations of nitrobenzene detected in groundwater samples are listed in the following table.

Nitrobenzene Concentrations ($\mu\text{g/L}$)

RFI Wells	Hydropunch II	
	Phase II	
	FG-9	1,000
	FG-13	569
	FG-14	7,980

4.2.3.6 Nitrogen Hydrocarbons

The following Nitrogen Hydrocarbons were detected in groundwater samples:

Acetonitrile
Ethyl cyanide

Acetonitrile

The maximum concentration of acetonitrile was 198,000 $\mu\text{g/L}$ in the FG-7 sample during Phase II of the investigation. It was detected in samples from 12 RFI wells during Phase I. It was also detected in 3 of the 12 wells sampled during Phase II, plus two other wells where it had not been detected during Phase I, and in 7 hydropunch samples. Concentrations of acetonitrile detected in groundwater samples are listed below.

Acetonitrile Concentrations ($\mu\text{g/L}$)

	RFI Wells		Hydropunch II	
	Phase I	Phase II	Phase II	
G-123S	18,700	ND	FG-1	101
G-124S	57	ND	FG-2	219
G-303	391	ND	FG-7	198,000
G-305	275	ND	FG-8	176
G-308	17.7	ND	FG-9	14,800
G-314	3,210	917	FG-11	722
G-324	74.6	ND	FG-12	15.6
G-330	ND	25.5	FG-15	140
G-332	1,860	1,560		
G-344	13.4	ND		
G-347	8.97	ND		
G-348	362	ND		
G-349	101	ND		

Ethyl Cyanide

The maximum concentration of ethyl cyanide was 52.6 $\mu\text{g/L}$ in the G-123S sample. Ethyl cyanide is an Appendix IX volatile. Ethyl cyanide was also detected at 14.1 $\mu\text{g/L}$ in the G-347 sample. Both detections occurred during Phase I of the investigation. No detections of ethyl cyanide were reported for the Phase II groundwater samples.

4.2.3.7 Phenols

The phenol compounds detected in groundwater samples included the following:

- 2,3,4,6-Tetrachlorophenol**
- 2,4,5-Trichlorophenol**
- 2,4,6-Trichlorophenol**
- 2,4-Dichlorophenol**
- 2,4-Dimethylphenol**
- 2,6-Dichlorophenol**
- 2-Chlorophenol**
- 2-Nitrophenol**
- Pentachlorophenol**
- Phenol**
- m+p Cresols**
- o-Cresols**
- p-Chloro-m-cresol**

2,3,4,6-Tetrachlorophenol

2,3,4,6-tetrachlorophenol was detected at a concentration of 19.3 $\mu\text{g/L}$ in the FG-5 sample during Phase II of the investigation. This was the only detection of this compound in groundwater samples.

2,4,5-Trichlorophenol

The maximum concentration of 2,4,5-Trichlorophenol was 29 µg/L detected in the G-344 sample during Phase I of the investigation. Concentrations of 2,4,5-Trichlorophenol detected in groundwater samples are listed below.

2,4,5 - Trichlorophenol Concentrations (µg/L)

RFI Wells		
	Phase I	Phase II
G-123S	28.2	ND
G-332	3.60	ND
G-344	29.0	ND
G-348	ND	26.8

2,4,6-Trichlorophenol

The maximum concentration of 2,4,6-Trichlorophenol was 878 µg/L detected in the FG-14 sample during Phase II of the investigation. Concentrations of 2,4,6-Trichlorophenol detected in the groundwater samples are listed below.

2,4,6 - Trichlorophenol Concentrations (µg/L)

RFI Wells			Hydropunch II	
	Phase I	Phase II	Phase II	
G-308	ND	26.2	FG-1	4.02
G-342	28.2	28.3	FG-5	62.7
G-343	ND	8.97	FG-6	3.62
G-344	3.6	28.3	FG-12	44.4
			FG-14	878
			FG-15	35.6

2,4-Dichlorophenol

The maximum concentration of 2,4-Dichlorophenol was 62,600 µg/L detected in the FG-14 sample during Phase II of the investigation. Concentrations of 2,4-Dichlorophenol detected in the groundwater are listed below.

2,4 - Dichlorophenol Concentrations (µg/L)

RFI Wells			Hydropunch II	
	Phase I	Phase II		Phase II
G-123S	334	ND	FG-1	193
G-302	21.5	ND	FG-2	73.9
G-307	4.56	ND	FG-3	2,000
G-308	283	1,280	FG-4	178
G-314	35.7	ND	FG-5	3,430
G-317	313	340	FG-6	228
G-330	22.6	53.2	FG-9	8,820
G-332	493	ND	FG-10	6.27
G-342	464	ND	FG-12	1,160
G-343	ND	24	FG-13	31,400
G-344	1,310	ND	FG-14	62,600
G-348	186	635	FG-15	458
G-349	94.4	294		

2,4-Dimethylphenol

The maximum concentration of 2,4-Dimethylphenol was 7,250 µg/L detected in the FG-14 sample during Phase II of the investigation. Concentrations of 2,4-Dimethylphenol detected in groundwater samples are listed in the following table.

2,4 - Dimethylphenol Concentrations ($\mu\text{g/L}$)

RFI Wells			Hydropunch II	
	Phase I	Phase II		Phase II
G-121S	31.0	ND	FG-1	21.3
G-308	21.9	77.9	FG-4	6.9
G-314	3.28	ND	FG-5	57.0
G-342	29.1	ND	FG-8	5.96
G-343	ND	4.96	FG-12	41.2
G-349	3.75	ND	FG-14	7,250

2,6-Dichlorophenol

The maximum concentration of 2,6-Dichlorophenol was 6,560 $\mu\text{g/L}$ detected in the FG-14 sample during Phase II of the investigation. Concentrations of 2,6-Dichlorophenol detected in groundwater samples are listed in the following table.

2,6 - Dichlorophenol Concentrations ($\mu\text{g/L}$)

RFI Wells			Hydropunch II	
	Phase I	Phase II		Phase II
G-308	14.4	ND	FG-1	57.5
G-317	53.1	ND	FG-2	18.8
G-332	ND	239	FG-3	390
G-342	288	350	FG-6	302
G-344	134	498	FG-9	1,460
G-349	13.4	ND	FG-12	250
		ND	FG-14	6,560

2 - Chlorophenol

The maximum concentration of 2 - Chlorophenol was 11,100 $\mu\text{g/L}$ detected in the FG-14 sample during Phase II of the investigation. Concentrations of 2 - Chlorophenol detected in groundwater samples are listed below.

2- Chlorophenol Concentrations ($\mu\text{g/L}$)

RFI Wells			Hydropunch II	
	Phase I	Phase II		Phase II
G-302	5.08	ND	FG-1	40.8
G-308	50.4	73.8	FG-3	583
G-314	ND	78.4	FG-4	31.6
G-317	ND	5.21	FG-5	469
G-324	ND	5.2	FG-6	14.7
G-330	ND	37.5	FG-8	39.3
G-332	ND	64.8	FG-12	247
G-342	671	1,100	FG-13	1,210
G-343	ND	8.52	FG-14	11,100
G-344	989	541	FG-15	8.21
G-348	2,730	1,590		
G-349	350	52.10		

2-Nitrophenol

2-Nitrophenol was detected at a concentration of 8.12 $\mu\text{g/L}$ in the G-343 sample during Phase I of the investigation. This was the only detection of this compound in all groundwater samples.

Pentachlorophenol

The maximum concentration of pentachlorophenol was 675 µg/L detected in the FG-14 sample during Phase II of the investigation. Concentrations of pentachlorophenol detected in groundwater samples are listed below.

Pentachlorophenol Concentrations (µg/L)

RFI Wells			Hydropunch II	
	Phase I	Phase II		Phase II
G-343	ND	9.06	FG-3	25.4
G-344	13.3	7.12	FG-5	260
			FG-13	260
			FG-14	675

Phenol

The maximum concentration of phenol was 67,700 µg/L detected in the G-342 sample during Phase I of the investigation. Concentrations of phenol detected in groundwater samples are listed below.

Phenol Concentrations (µg/L)

RFI Wells			Hydropunch II	
	Phase I	Phase II		Phase II
G-302	24.5	ND	FG-1	868
G-303	7.04	ND	FG-2	126
G-308	236	553	FG-3	5,490
G-314	403	64.1	FG-4	577
G-317	378	183	FG-5	7,510
G-324	715	59.5	FG-6	1,400
G-330	22.0	77.9	FG-7	19,900
G-332	4,590	2,330	FG-8	668

Phenol Concentrations ($\mu\text{g/L}$)

RFI Wells			Hydropunch II	
	Phase I	Phase II	Phase II	
G-342	67,700	42,200	FG-9	10,100
G-344	4,290	3,570	FG-10	56.1
G-348	231	25.1	FG-12	5,120
G-349	350	547	FG-13	403
			FG-14	16,800
			FG-15	90

m+p Cresol

The maximum concentration of m+p cresol was 35,500 $\mu\text{g/L}$ detected in the FG-14 sample during Phase II of the investigation. Concentrations of m+p cresol detected in the groundwater are listed below.

m+p Cresol Concentrations ($\mu\text{g/L}$)

RFI Wells			Hydropunch II	
	Phase I	Phase II		Phase II
G-308	188	452	FG-1	248
G-314	243	232	FG-3	2,270
G-317	68.8	26.3	FG-4	122
G-324	221	19.2	FG-6	31.3
G-330	30.7	78.8	FG-8	123
G-342	339	ND	FG-9	1,160
G-344	514	37.6	FG-12	543
G-348	233	ND	FG-14	35,500
G-349	42.8	81.5	FG-15	13.5

o - Cresol

The maximum concentration of o - Cresol was 721 $\mu\text{g/L}$ detected in the FG-5 sample during Phase II of the investigation. Concentrations of o - Cresol detected in the groundwater are listed below.

o - Cresol Concentrations ($\mu\text{g/L}$)

RFI Wells			Hydropunch II	
	Phase I	Phase II		Phase II
G-308	11.8	18.1	FG-5	721
G-344	86.4	36.0	FG-14	37.1
G-349	13.1	11.9		

p-Chloro-m-cresol

p-Chloro-m-cresol was detected at a concentration of 6.23 $\mu\text{g/L}$ detected in the G-343 sample during Phase II of the investigation. This was the only detection of this compound in all groundwater samples.

4.1.3.8 Polyaromatic Hydrocarbons

Polyaromatic hydrocarbons detected in groundwater samples included the following:

- 2 - Methylanthracene
- Acenaphthene
- Anthracene
- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Benzo(ghi)perylene
- Chrysene
- Fluoranthene
- Fluorene
- Indeno(1,2,3-c,d)pyrene
- Naphthalene
- Phenanthrene
- Pyrene

2 - Methylanthracene

The maximum concentration of 2 - methylanthracene was 29.1 $\mu\text{g/L}$ detected in the FG-3 sample during Phase II of the investigation. The FG-15 sample was the only other groundwater sample where 2 - methylanthracene was detected. The detected concentration in the FG-15 sample was 12.70 $\mu\text{g/L}$.

Acenaphthene

The maximum concentration of acenaphthene was 14.40 $\mu\text{g/L}$ detected in the G-308 sample during Phase II of the investigation. Concentrations of acenaphthene detected in groundwater samples are listed below.

Acenaphthene Concentrations ($\mu\text{g/L}$)

RFI Wells			Hydropunch II	
	Phase I	Phase II		Phase II
G-120S	ND	4.23	FG-1	2.23
G-121S	ND	2.28	FG-2	4.44
G-303	3.14	ND	FG-3	8.82
G-308	8.37	14.40	FG-8	5.08
G-317	ND	2.22		
G-324	ND	4.64		
G-336	ND	2.53		
G-344	3.51	3.51		

Anthracene

The maximum concentration of anthracene was 17.40 $\mu\text{g/L}$ detected in the FG-3 sample during Phase II of the investigation. Concentrations of anthracene detected in the groundwater are listed in the following table.

Anthracene Concentrations ($\mu\text{g/L}$)

RFI Wells			Hydropunch II	
	Phase I	Phase II		Phase II
G-308	2.26	ND	FG-2	3.07
G-332	ND	2.52	FG-3	17.40

Benzo(a)anthracene

Benzo(a)anthracene was detected at a concentration of 17.6 $\mu\text{g/L}$ in the FG-3 sample during Phase II of the investigation. This was the only detection of this compound in groundwater samples.

Benzo(a)pyrene

Benzo(a)pyrene was detected at a concentration of 15.0 $\mu\text{g/L}$ in the FG-3 sample during Phase II of the investigation. This was the only detection of this compound in groundwater samples.

Benzo(b)fluoranthene

The maximum concentration of benzo(b)fluoranthene was 18.9 $\mu\text{g/L}$ detected in the FG-3 sample during Phase II of the investigation. The FG-2 sample was the only other groundwater sample where benzo(b)fluoranthene was detected at a concentration of 11.10 $\mu\text{g/L}$.

Benzo(ghi)perylene

Benzo(ghi)perylene was detected at a concentration of 10.4 $\mu\text{g/L}$ in the FG-3 sample during Phase II of the investigation. This was the only detection of this compound in groundwater samples.

Chrysene

The maximum concentration of chrysene was 17.10 $\mu\text{g/L}$ detected in the FG-3 sample during Phase II of the investigation. The FG-2 sample was the only other groundwater sample where chrysene was detected. The detected concentration in the FG-2 sample was 9.19 $\mu\text{g/L}$.

Fluoranthene

The maximum concentration of fluoranthene was 55.3 µg/L detected in the FG-3 sample during Phase II of the investigation. Concentrations of fluoranthene detected in groundwater samples are listed below.

Fluoranthene Concentrations (µg/L)

RFI Wells			Hydropunch II	
	Phase I	Phase II		Phase II
G-308	5.56	6.23	FG-2	15.3
			FG-3	55.3

Fluorene

The maximum concentration of fluorene was 9.8 µg/L detected in the FG-3 sample during Phase II of the investigation. Concentrations of fluorene detected in groundwater samples are listed below.

Fluorene Concentrations (µg/L)

RFI Wells			Hydropunch II	
	Phase I	Phase II		Phase II
G-120S	ND	4.73	FG-1	2.18
G-308	4.57	9.78	FG-2	4.83
G-317	3.72	ND	FG-3	9.8
G-324	ND	2.8		
G-344	2.47	4.85		

Indeno(1,2,3-c,d)pyrene

Indeno(1,2,3-c,d)pyrene was detected at a concentration of 11.3 µg/L in the FG-3 sample during Phase II of the investigation. This was the only detection of this compound in groundwater samples.

Naphthalene

The maximum concentration of naphthalene was 112 µg/L detected in the FG-7 sample during Phase II of the investigation. Concentrations of naphthalene detected in groundwater samples are listed below.

Naphthalene Concentrations (µg/L)

RFI Wells			Hydropunch II	
	Phase I	Phase II		Phase II
G-121S	6.96	12.0	FG-1	22.4
G-302	2.36	ND	FG-2	25.6
G-303	2.78	ND	FG-3	66.2
G-308	31.8	85.6	FG-4	5.68
G-314	2.61	ND	FG-7	112
G-317	24.0	9.22	FG-8	9.92
G-324	46.5	16.7	FG-10	3.25
G-330	6.20	5.99	FG-12	41.8
G-332	ND	25.0	FG-15	46.3
G-344	98.7	74.8		
G-348	42.14	25.0		
G-349	7.81	62.1		

Phenanthrene

The maximum concentration of phenanthrene was 61.7 $\mu\text{g/L}$ detected in the FG-3 sample during Phase II of the investigation. Concentrations of phenanthrene detected in groundwater samples are listed below.

Phenanthrene Concentrations ($\mu\text{g/L}$)

RFI Wells			Hydropunch II	
	Phase I	Phase II		Phase II
G-308	12.8	22.9	FG-2	24.6
G-317	9.12	ND	FG-3	61.7

Pyrene

The maximum concentration of pyrene was 59.8 $\mu\text{g/L}$ detected in the FG-3 sample during Phase II of the investigation. Concentrations of pyrene detected in the groundwater are listed below.

Pyrene Concentrations ($\mu\text{g/L}$)

RFI Wells			Hydropunch II	
	Phase I	Phase II		Phase II
G-308	4.46	4.0	FG-2	11.9
G-317	2.64	ND	FG-3	59.8
			FG-8	2.55

4.2.3.9 Miscellaneous Hydrocarbons

Miscellaneous hydrocarbons are a collection of organic constituents not found in any of the other chemical groups. The concentrations of these constituents were not summed and listed in Tables 4-5 and 4-6 because constituents are not necessarily related. Miscellaneous hydrocarbons include the following:

1,4-Dioxane
Acrolein
Bis-(2-Ethyhexyl)-phthalate
Carbon disulfide
Di-n-butyl-phthalate
Isobutyl alcohol
Phorate

1,4 Dioxane

The maximum concentration of 1,4-Dioxane was 2,180 $\mu\text{g/L}$ in the FG-3 sample detected during Phase II of the investigation. 1,4-Dioxane is an Appendix IX volatile. Concentrations of 1,4-Dioxane detected in groundwater samples are listed below.

1,4 Dioxane Concentrations ($\mu\text{g/L}$)

RFI Wells			Hydropunch II	
	Phase I	Phase II		Phase II
G-123S	426	ND	FG-2	301
G-308	39.3	ND	FG-3	2,180
G-347	82.7	ND		

Acrolein

Acrolein was detected at a concentration of 97.5 $\mu\text{g/L}$ in the G-330 sample during Phase I of the investigation. This was the only detection reported for the Phase I groundwater samples.

Bis-(2-Ethyhexyl)-phthalate

The maximum concentration of bis-(2-Ethyhexyl)-phthalate was 12.7 $\mu\text{g/L}$ in the G-347 sample detected during Phase I of the investigation. The G-336 and G-344 samples also detected bis-(2-Ethyhexyl)-phthalate at concentrations of 12.4 $\mu\text{g/L}$ and 11.5 $\mu\text{g/L}$ during Phase I. Bis (2-Ethyhexyl) phthalate was detected in the FG-8 sample at a concentration of 38.0 $\mu\text{g/L}$ during Phase II of the investigation. Phthalates are common laboratory artifacts.

Carbon disulfide

Carbon disulfide was detected at a concentration of 15.1 $\mu\text{g/L}$ in the G-308 sample during Phase II of the investigation. Carbon disulfide is an Appendix IX volatile. This constituent was not detected in the G-308 sample during Phase I. This was the only detection of this compound in groundwater samples.

Di-n-butyl-phthalate

The only detection of di-n-butyl-phthalate was 52.7 $\mu\text{g/L}$ in the G-317 sample detected during Phase II of the investigation. No detections of di-n-butyl-phthalate were reported in the G-317 sample collected during Phase I. Phthalates are common laboratory artifacts.

Isobutyl alcohol

The maximum concentration of isobutyl alcohol was 3,720 $\mu\text{g/L}$ in the G-332 sample detected during Phase II of the investigation. Isobutyl alcohol is an Appendix IX volatile. Isobutyl alcohol was not detected in any of the Hydropunch II groundwater samples. Concentrations of isobutyl alcohol detected in the groundwater are listed in the following table.

Isobutyl alcohol Concentrations ($\mu\text{g/L}$)

RFI Wells		
	Phase I	Phase II
G-332	2,460	3,720
G-347	ND	21.2

Phorate

Phorate was detected at a concentration of $3.01 \mu\text{g/L}$ in the G-348 sample during Phase I of the investigation. Phorate is classified as a pesticide. This was the only detection in all Phase I groundwater samples. Analysis for phorate was not performed for Phase II groundwater samples.

4.2.4 Groundwater Contamination Characterization

Groundwater samples collected during both phases of the investigation from the RFI wells indicate that groundwater in the upper most water bearing unit (the fill material) has been impacted by former waste management practices. The RFI wells were placed in and around the former SWMUs.

Detection of inorganic compounds, including metals, do not indicate a contaminant distribution pattern. (The fill material appears to have a greater influence on the occurrence of metals in the groundwater than the SWMUs.) Virtually all metals were detected in upgradient RFI well samples (G-307, G-334, G-343, and G-347). Additionally, metals were detected in the surface soil samples collected on the pier. A range of background concentrations is listed in Table 2-1, Section 2.0, Part 3 of this report.

Organic constituents proved most useful in defining groundwater contamination in the upper most water bearing unit. In general, the highest concentrations and number of constituents detected in groundwater samples were from the wells located within the SWMU boundaries. This was confirmed during Phase II of the investigation by collecting additional groundwater samples with a Hydropunch II sampling device within the SWMUs. RFI and Hydropunch groundwater sample locations by SWMUs have been summarized in Table 4-1.

Several organic constituents were also detected in upgradient RFI wells G-307, G-334, G-343, and G-347. (see Table 2-1, Section 2.0, Part 3 of this report). However, concentrations and frequency of occurrence of these organic compounds are insignificant relative to the other RFI wells. A clear distinction of the contamination between these upgradient RFI wells, the RFI wells located in or near the SWMUs, and RFI wells located between the SWMUs and Lake Calumet exists. G-349 is an exception. G-349 is located at the southeast corner of the facility. Upgradient sources for this well would be outside the facility. No off-site SWMUs were

investigated, but organic compounds were detected in samples collected from this well during both phases of the investigation. Groundwater contamination in this area is likely the result of a source other than one of the identified SWMUs.

To characterize the contaminant distribution pattern, six organic constituents and one metal were selected. Benzene, 1,1-dichloroethylene, phenol, 2,4-dichlorophenol, naphthalene, acenaphthene, and arsenic were selected since these constituents were the most frequently occurring compounds in the groundwater. Isoconcentration maps of the concentrations detected in groundwater and surface water have been created. These maps have been included in Appendix L.

The highest concentrations of benzene for both phases were detected at sample locations in and around the Biobeds (SWMU #1), the former Wastewater Basin #2 (SWMU #6), the former Hyon Tank Farm, the G-349 location, and on the north and east sides of the stabilization basins. The highest concentrations of 1,1-dichloroethylene was detected at sample locations in and around the Biobeds (SWMU #1), the Wastewater Basin #2 (SWMU #6), and the former Hyon Tank Farm. Similarly, the highest concentrations of phenol, 2,4-dichlorophenol, and naphthalene were detected at sample locations in and around SWMU #1, SWMU #6, and the Hyon Tank Farm. Acenaphthene was detected in three locations during phase I. These include the former Hyon Tank Farm, the High Solids Basin (SWMU #4), and SWMU #6. During Phase II, Acenaphthene was detected in SWMU #1, SWMU #4, and SWMU #6.

These logarithmic isoconcentration maps all indicate that concentrations of organic compounds decrease significantly away from the SWMUs. Additionally, these maps identify groundwater contamination in the areas of SWMU #1, SWMU #4, SWMU #6, and the former Hyon Tank Farm.

The natural logarithm of arsenic concentrations was also used to create an isoconcentration map. Arsenic was found at virtually all sample locations. The isoconcentration map indicates that the concentrations of arsenic vary. This does not identify groundwater contamination in the areas of SWMU #4, SWMU #6, and the Hyon Tank Farm as clearly as the organic compounds.

Groundwater contamination in the Biobeds area (SWMU #1) and the former Wastewater Basin #2 (SWMU #6) is the result of former waste management practices. Fluids from these lagoons were removed and properly disposed. Sludges were excavated, solidified, and placed in the clay-lined vault constructed at the location of the former Wastewater Basin #2 (SWMU #5). The work was done as part of the pier restoration project completed in 1982. Groundwater contamination was likely present prior to this work. Residual waste remaining in the lagoons continues to impact groundwater quality of the uppermost water bearing unit (fill).

Groundwater contamination was also encountered in the vicinity of the former Hyon Tank Farm. This includes the presence of chlorobenzenes detected in the FG-14 sample not previously seen in this area.

Upon further evaluation of the hydrogeologic conditions of the fill, several factors contribute to restricting the release of contaminated groundwater to the lake. These factors include:

1. A wide range of hydraulic conductivity values calculated from on-site monitoring wells. Hydraulic conductivity values were highest in RFI wells screened across sandy fill material. Sandy fill material was not encountered in all borings advanced in the fill. Lower hydraulic conductivity values were found in RFI wells not screened across sandy layers. This indicates that continuous layers of sandy fill material may not be present.
2. Two groundwater mounds were observed during the investigation. One is centered in the area of the Biobeds (SWMU #1), and another is centered in the area of former Wastewater Basin #2 (SWMU #6). Fine-grained soils were encountered below groundwater in borings advanced in these areas. The fine-grained soils are likely

remnants of soil used to line the former lagoons. The former lagoon liners are restricting the migration of groundwater creating the mounds.

4.2.5 Groundwater Model

Groundwater modelling was performed to determine the volume of water discharging into the lake. Additionally, contaminant transport calculations were made.

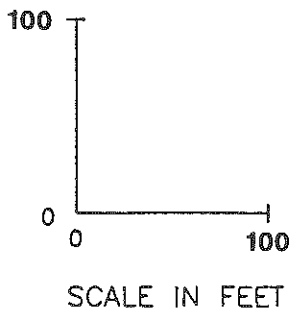
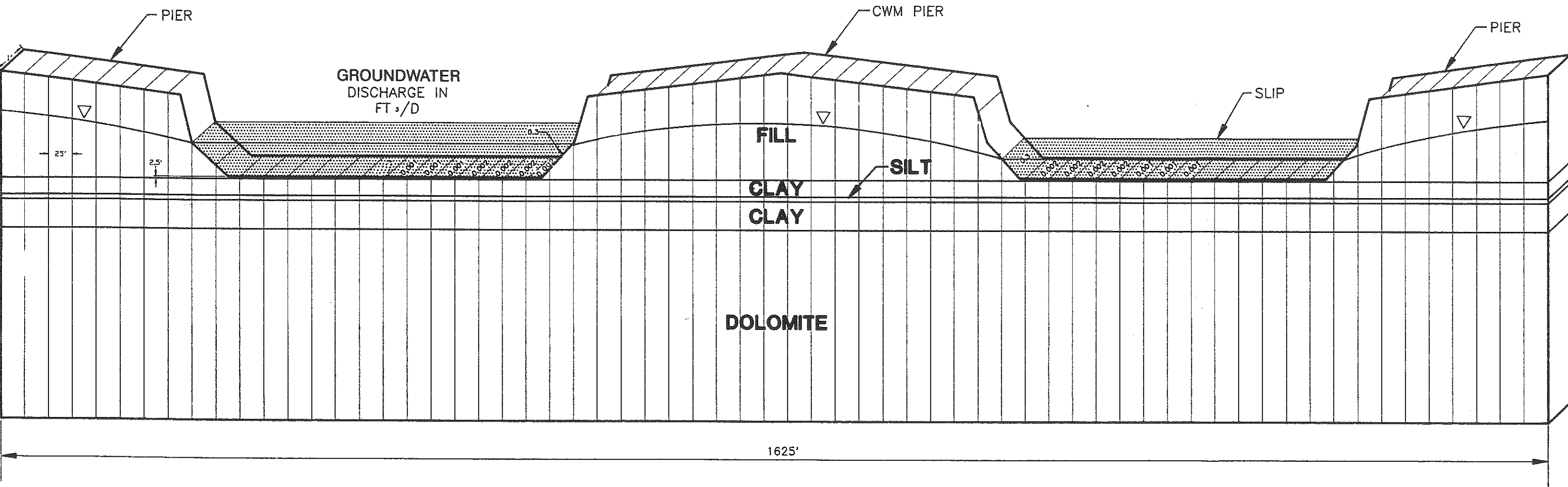
A consideration of the flux from the CWMCS pier into Lake Calumet requires a three-dimensional perspective, which considers the vertically-variable conditions at the site. Consequently, a single-equation calculation is not an appropriate approach. Based upon this understanding, the USGS finite difference groundwater flow model MODFLOW was selected to simulate the groundwater flux into Lake Calumet from the pier.

4.2.5.1 Model Configuration

The potential discharge of benzene into Lake Calumet was assessed by use of a groundwater flow model. MODFLOW was used to simulate a 1-foot-wide "slice," extending from the centers of the adjacent piers, through the slips and the CWMCS pier at well P-316. The location of the modeled section was selected due to the large hydraulic gradient at that location of the pier. Because hydraulic gradient is one of the primary components in advective transport, this in effect, simulates the worst-case scenario. Figure 4-1 illustrates the model configuration. As the figure indicates, the model consisted of one row, 65 columns and five layers. The columns were a uniform width of 25 feet. The layers represented the stratigraphic layers identified during the site Remedial Investigation (RI), which included (from the top):

1. Fill materials;
2. Clay (upper lacustrine);
3. Silt (lower lacustrine);
4. Clay (glacial till); and
5. Dolomite.

NORTH SOUTH



CWM CHEMICAL SERVICES INC. CHICAGO INCINERATOR FEB. 23 1993	
FIGURE 4-1 SIMULATED GROUNDWATER FLUX INTO LAKE CALUMET	
DRN. BY MAR	PROJ. NO. 13963-055
DATE OCT. 1993	DAMES & MOORE

The basic input file (BAS) and the block-centered-flow file (BCF) are presented in Appendix M. The BCF file indicates the simulated permeabilities. These were based upon the averages for each of layers 1 through 4, as presented in the RI report. The permeability of the dolomite was taken from Freeze and Cherry (1979); an arbitrary thickness of 200 feet was simulated for the dolomite. The values used are summarized as follows:

LAYER	SIMULATED HYDRAULIC CONDUCTIVITY	SIMULATED THICKNESS
1	0.28 ft/d	Variable
2	5.7E-5 ft/d	17.5 ft
3	8.0E-4 ft/d	5.0 ft
4	1.9E-3 ft/d	30.0 ft
5	1.5E-5 ft/d	200.0 ft

The model simulates a no-flow condition on all four vertical sides and at the base. This condition is appropriate through the CWMCS pier because the model section is aligned parallel to groundwater flow; the condition is appropriate at the north and south model boundaries (left and right, respectively), because they terminate at an assumed groundwater divide. Constant head (0.0 feet, City of Chicago datum) was simulated for layer 1 where it passes through the slips.

Because simulated hydraulic conductivity values were determined based upon field observations, these were held constant and the model was calibrated to observed water levels by means of adjusting the simulated recharge value. The recharge to the model was determined to be approximately 6 inches per year, which is typical for the area.

4.2.5.2 Results

The model output is provided in Appendix M. The model output indicates the simulated flow from the constant head cells (cells representing the slips in layer 1). These flows are reproduced in Table 4-7. The individual flows (rates) are in terms of ft³/day/cell. This results in a discharge of 5.2×10^{-5} ft³/day/ft² midway between the CWMCS pier and the adjacent piers, to 0.012 ft³/day/ft², in the cells immediately adjacent to the CWMCS pier.

The benzene concentrations detected in samples collected from well G314 (worst-case Phase II scenario) were used to compute a release to Lake Calumet. No retardation or natural decay were considered in the calculations. As shown in Table 4-7, a groundwater flow of approximately 0.6 cubic feet per day per linear foot of pier has been modeled. At a concentration of 1,050 µg/L, 1000 linear feet of pier would discharge 7 lb/year of benzene into Lake Calumet.

4.2.5.3 Conclusions

A worst-case scenario was simulated, based upon observed hydrogeological and groundwater chemistry conditions at the CWMCS pier. The model simulated a flux into Lake Calumet which decreases with distance from the pier. This is consistent with the conventional understanding of groundwater-surface water interactions (see, for example, McBride and Phannkuch, 1975 and Winter, 1978). Additionally, no retardation or decay was considered; consequently, benzene was considered as a conservative compound, transported advectively. When these conditions are considered, the actual discharge of benzene (and, consequently, other compounds) to Lake Calumet is likely very low.

TABLE 4-7
CELL-BY-CELL FLOW TERMS
GROUNDWATER DISCHARGE INTO LAKE CALUMET
(Discharge rates are in ft³/day)

CONSTANT HEAD	PERIOD	1	STEP	1	LAYER	1	ROW	1	COL	9	RATE	0.2692417
CONSTANT HEAD	PERIOD	1	STEP	1	LAYER	1	ROW	1	COL	10	RATE	0.2251459E-03
CONSTANT HEAD	PERIOD	1	STEP	1	LAYER	1	ROW	1	COL	11	RATE	0.1952136E-03
CONSTANT HEAD	PERIOD	1	STEP	1	LAYER	1	ROW	1	COL	12	RATE	0.1723992E-03
CONSTANT HEAD	PERIOD	1	STEP	1	LAYER	1	ROW	1	COL	13	RATE	0.1546899E-03
CONSTANT HEAD	PERIOD	1	STEP	1	LAYER	1	ROW	1	COL	14	RATE	0.1415641E-03
CONSTANT HEAD	PERIOD	1	STEP	1	LAYER	1	ROW	1	COL	15	RATE	0.1327259E-03
CONSTANT HEAD	PERIOD	1	STEP	1	LAYER	1	ROW	1	COL	16	RATE	0.1279827E-03
CONSTANT HEAD	PERIOD	1	STEP	1	LAYER	1	ROW	1	COL	17	RATE	0.1272405E-03
CONSTANT HEAD	PERIOD	1	STEP	1	LAYER	1	ROW	1	COL	18	RATE	0.1305107E-03
CONSTANT HEAD	PERIOD	1	STEP	1	LAYER	1	ROW	1	COL	19	RATE	0.1379146E-03
CONSTANT HEAD	PERIOD	1	STEP	1	LAYER	1	ROW	1	COL	20	RATE	0.1496922E-03
CONSTANT HEAD	PERIOD	1	STEP	1	LAYER	1	ROW	1	COL	21	RATE	0.1662273E-03
CONSTANT HEAD	PERIOD	1	STEP	1	LAYER	1	ROW	1	COL	22	RATE	0.1882211E-03
CONSTANT HEAD	PERIOD	1	STEP	1	LAYER	1	ROW	1	COL	23	RATE	0.2182105E-03
CONSTANT HEAD	PERIOD	1	STEP	1	LAYER	1	ROW	1	COL	24	RATE	0.2856787
CONSTANT HEAD	PERIOD	1	STEP	1	LAYER	1	ROW	1	COL	42	RATE	0.2857846
CONSTANT HEAD	PERIOD	1	STEP	1	LAYER	1	ROW	1	COL	43	RATE	0.2216635E-03
CONSTANT HEAD	PERIOD	1	STEP	1	LAYER	1	ROW	1	COL	44	RATE	0.1902837E-03
CONSTANT HEAD	PERIOD	1	STEP	1	LAYER	1	ROW	1	COL	45	RATE	0.1667213E-03
CONSTANT HEAD	PERIOD	1	STEP	1	LAYER	1	ROW	1	COL	46	RATE	0.1485262E-03
CONSTANT HEAD	PERIOD	1	STEP	1	LAYER	1	ROW	1	COL	47	RATE	0.1349959E-03
CONSTANT HEAD	PERIOD	1	STEP	1	LAYER	1	ROW	1	COL	48	RATE	0.1257200E-03
CONSTANT HEAD	PERIOD	1	STEP	1	LAYER	1	ROW	1	COL	49	RATE	0.1204254E-03
CONSTANT HEAD	PERIOD	1	STEP	1	LAYER	1	ROW	1	COL	50	RATE	0.1189570E-03
CONSTANT HEAD	PERIOD	1	STEP	1	LAYER	1	ROW	1	COL	51	RATE	0.1212742E-03
CONSTANT HEAD	PERIOD	1	STEP	1	LAYER	1	ROW	1	COL	52	RATE	0.1274502E-03
CONSTANT HEAD	PERIOD	1	STEP	1	LAYER	1	ROW	1	COL	53	RATE	0.1376752E-03
CONSTANT HEAD	PERIOD	1	STEP	1	LAYER	1	ROW	1	COL	54	RATE	0.1522769E-03
CONSTANT HEAD	PERIOD	1	STEP	1	LAYER	1	ROW	1	COL	55	RATE	0.1718832E-03
CONSTANT HEAD	PERIOD	1	STEP	1	LAYER	1	ROW	1	COL	56	RATE	0.1988606E-03
CONSTANT HEAD	PERIOD	1	STEP	1	LAYER	1	ROW	1	COL	57	RATE	0.2688439

4.2.6 Vault Leachate

The vault is located where the former Wastewater Basin #1 (SWMU #5) was located. Sludges were excavated from the basins and temporarily stockpiled on-site. An engineered clay lined vault was constructed. Sludges excavated from the basin and from other SWMUs were returned to the vault. This work was completed as part of the site restoration project (6).

Leachate samples were collected from four locations in the vault during Phase II of the investigation. The samples were collected with a Hydropunch II sampling device. Recharge in the vault was considerably slower compared to recharge at other hydropunch locations in the fill. Several months were required to collect samples at all four locations. Samples were analyzed for full Appendix IX constituents. Concentrations of detected constituents for leachate samples L-1 through L-4 are included in Appendix K. Volatiles were collected from a hand auger boring during Phase I. Detected concentrations for the V-1 sample are also included in Appendix K.

Leachate sample results have been compared to groundwater sample results from three RFI wells located near the vault. Well G-336 is approximately 75 feet south of the L-1 sample location. Well G-318 is approximately 50 feet north of the L-2 sample location. (Well G-318 is located near the center of the pier, east of the vault.) Well G-302 is between the vault and Slip No. 6 (Lake Calumet). Well G-336 is between the vault and Slip No. 8 (Lake Calumet). On either side of the vault, a groundwater divide is present along the long axis of the pier. Groundwater flow on the north half of the pier is to the north towards Lake Calumet. On the south half of the pier, the groundwater flow direction is to the south towards Lake Calumet.

The concentrations of inorganic constituents detected in the leachate samples collected during Phase 2, and groundwater samples collected during both phases of the investigation are summarized in Table 4-8. Similarly, concentrations of organic constituents are summarized in Table 4-9.

TABLE 4-8
VAULT LEACHATE AND GROUNDWATER
INORGANICS AND METALS

	L-1	G-336 Phase 1	G-336 Phase 2	L-2	G-302 Phase 1	G-302 Phase 2	L-3	G-318 Phase 1	G-318 Phase 2	L-4
Antimony, total	50.00	ND	ND	ND	99.00	ND	ND	ND	ND	ND
Arsenic, total	110.00	68.00	ND	ND	150.00	ND	220.00	78.00	ND	180.00
Barium, total	2000.00	720.00	86.00	470.00	1200.00	74.00	520.00	510.00	ND	1100.00
Beryllium, total	9.10	4.90	ND	3.10	15.00	ND	2.50	3.70	ND	15.00
Cadmium, total	60.00	38.00	NA	4.50	60.00	NA	4.80	10.00	NA	1142.00
Cobalt, total	24.00	47.00	ND	3.40	90.00	ND	8.90	91.00	ND	130.00
Copper, total	3180.00	520.00	ND	2.90	510.00	ND	31.10	160.00	ND	1280.00
Lead, total	8190.00	1100.00	ND	170.00	2400.00	ND	26.00	350.00	ND	2200.00
Mercury, total	2.50	0.70	ND	ND	0.33	ND	0.40	0.39	ND	1.20
Nickel, total	1100.00	140.00	ND	580.00	270.00	ND	2160.00	160.00	ND	1200.00
Selenium, total	ND	5.60	ND	ND	ND	ND	300.00	ND	ND	140.00
Tin, total	ND	NA	190.00	480.00	NA	ND	1300.00	NA	ND	ND
Vanadium, total	190.00	190.00	ND	49.00	340.00	ND	370.00	160.00	ND	260.00
Zinc, total	38300.00	1300.00	NA	1700.00	2000.00	NA	2800.00	390.00	NA	10700.00
Cyanide, total	64.40	NA	NA	94.70	NA	NA	127.00	NA	NA	33.60

ND - Nondetect
All concentrations in µg/l
NA - Not analyzed

cwm/table.4-7

Significant concentrations of organic and inorganic constituents are present in the leachate. Inorganic constituents of relatively low concentrations, approximately two orders of magnitude less than those detected in the leachate, are present in both Phase I and Phase II groundwater samples. A decrease in the concentration of inorganic constituents in groundwater samples collected between Phase I and Phase II is present. This decrease is not considered significant. A clear delineation between vault leachate and groundwater is apparent. This is characterized by the high concentrations found in the leachate (organic and inorganic) and the relatively low concentrations found in the groundwater samples. Based on these results, it does not appear as if leachate is migrating from the vault into groundwater. Organic constituents in the groundwater are likely the result of contamination from the former Wastewater Basin (SWMU #5).

4.3 Soils Contaminant Characterization

No naturally occurring soils are present above the uppermost water bearing unit. The uppermost water bearing unit is the fill, an engineered surface on which the facility rests. The fill is composed of construction debris, foundry sand, and slag. The active area of the incinerator area lies at the former shoreline of Lake Calumet. The remainder of the facility is a pier structure extending into Lake Calumet. Each SWMU constructed was within or on the fill material. Background information on each SWMU has been presented in Section 3 of Part I of this report.

For the purposes of this investigation soils sample are divided into two groups, fill and clay. Fill samples are samples of the fill material used to construct the pier and engineered surface of the active area. Clay samples refer to the lacustrine and glacial till deposits beneath the fill material.

4.3.1 Clay Results

Samples of the fine grained soils, or clay beneath the fill material were collected during both phases of the investigation. These samples were analyzed for the entire Appendix IX list. Laboratory reports have been included in Appendix K. Results have been summarized in Tables 4-10 through 4-19.

Clay sample locations, sample horizons, and sampling methods differed between Phase I and Phase II. Sample locations for each SWMU by matrix are shown in Table 4-1. Sample horizons and sampling methods are described below.

Sample Horizons

Phase I clay samples were collected at two horizons. The first horizon (C1) is at the clay/fill contact, and the second (C2) horizon is ten feet below the clay/fill contact. Phase II clay samples were collected at 3 horizons referred to as shallow, intermediate, and deep. Each horizon corresponds to a stratigraphic soil unit. The shallow horizon sample was collected five feet below the clay/fill contact in the upper lacustrine unit. The intermediate sample was collected fifteen feet below the clay/fill contact in the lower lacustrine unit. The deep sample was collected forty feet below the clay/fill horizon in the glacial till unit.

Sample Methods

All soil samples were collected via split-spoon samplers from bore holes. During Phase I of the investigation, boreholes were advanced using hollow stem augers. Clay samples were recovered from boreholes by withdrawing the sampler through a drilling mud (bentonite and groundwater) mix. Laboratory results indicate that cross-contamination of the clay samples from contaminated fill and groundwater saturating the fill likely occurred. As a result, Phase II samples were collected with a double-cased method by sealing off the upper aquifer with a large diameter

TABLE 4-10
CLAY PHASE I METALS AND INORGANICS *
LEVEL 1

Metals	B-304 C1	P-316 C1	G-318 C1	P-319 C1	P-322 C1	P-323 C1	B-328 C1	B-341 C1	B-346 C1
Antimony	11.00	26.00	23.00	12.00	12.00	18.00	16.00	11.00	15.00
Arsenic	9.40	9.10	6.30	4.80	6.00	5.40	13.00	6.00	18.00
Barium	48.00	40.00	43.00	52.00	64.00	50.00	35.00	50.00	38.00
Beryllium	0.61	0.41	0.43	0.67	0.67	0.65	0.57	0.63	1.00
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND	0.34
Chromium	20.00	15.00	16.00	22.00	21.00	21.00	18.00	21.00	26.00
Cobalt	11.00	10.00	9.80	12.00	11.00	11.00	12.00	9.70	13.00
Copper	22.00	26.00	27.00	25.00	22.00	19.00	28.00	18.00	36.00
Lead	17.00	13.00	17.00	13.00	12.00	12.00	16.00	26.00	28.00
Mercury	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	29.00	28.00	29.00	33.00	29.00	29.00	33.00	27.00	36.00
Thallium	ND	ND	ND	ND	ND	ND	ND	ND	1.80
Tin	8.60	7.40	ND	12.00	ND	ND	9.70	8.80	14.00
Vanadium	23.00	19.00	20.00	26.00	25.00	25.00	21.00	25.00	46.00
Zinc	50.00	54.00	110.00	55.00	51.00	50.00	57.00	87.00	150.00
Inorganics									
Cyanide, total	< 0.61	< 0.62	< 0.62	< 0.61	< 0.63	< 0.63	< 0.63	< 0.62	< 0.63
Sulfide as S	< 5.70	< 5.30	< 5.80	< 6.00	< 6.10	< 5.80	6.50	< 5.70	< 5.80
Sample Depth (feet)	18-20	21-23	18-20	19-21	18-20	14-16	16-18	14-16	14-16

* Data has been invalidated; see text.

ND - Nondetect

Sample depth - feet below grade

All concentrations in mg/kg

TABLE 4-11
CLAY PHASE I METALS AND INORGANICS *
LEVEL 2

Metals	B-304 C2	P-316 C2	G-318 C2	P-319 C2	P-322 C2	P-323 C2	B-328 C2	B-341 C2	B-346 C2
Antimony	14.00	21.00	20.00	9.20	21.00	17.00	14.00	8.40	11.00
Arsenic	7.00	9.10	5.10	6.90	3.60	14.00	16.00	5.70	7.90
Barium	50.00	58.00	43.00	51.00	74.00	24.00	18.00	54.00	40.00
Beryllium	0.65	0.44	0.37	0.46	0.88	0.45	0.40	0.67	0.52
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chromium	22.00	27.00	17.00	17.00	27.00	13.00	12.00	22.00	18.00
Cobalt	13.00	8.20	8.80	9.10	13.00	15.00	12.00	11.00	11.00
Copper	29.00	23.00	20.00	21.00	23.00	46.00	45.00	22.00	24.00
Lead	16.00	24.00	12.00	46.00	13.00	18.00	21.00	17.00	14.00
Mercury	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	35.00	25.00	26.00	25.00	35.00	38.00	30.00	30.00	29.00
Thallium	ND	ND	ND	ND	ND	ND	1.20	ND	ND
Tin	12.00	ND	6.50	9.90	ND	5.80	6.20	10.00	7.40
Vanadium	26.00	23.00	20.00	18.00	30.00	17.00	16.00	24.00	21.00
Zinc	57.00	71.00	51.00	66.00	59.00	60.00	71.00	58.00	50.00
Inorganics									
Cyanide, total	< 0.63	< 0.85	< 0.61	< 0.66	< 0.78	< 0.63	< 0.56	< 0.61	< 0.60
Sulfide as S	< 6.00	< 6.40	< 6.00	7.50	< 6.90	< 5.70	< 5.40	< 5.90	< 6.00
Sample Depth (feet)	26-28	28-31	26-31	26-29	28-30	22-27	22-24	22-24	24-26

* Data invalidated; see text.

ND - Nondetect

Sample depth - feet below grade

All concentrations in mg/kg

TABLE 4-12
CLAY PHASE II METALS
SHALLOW

METALS	C-1	C-2	C-2R	C-3	C-4	C-5	C-6	C-7
Antimony	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	8.00	6.70	5.80	9.80	8.50	5.10	9.60	8.20
Barium	47.00	46.00	46.00	37.00	50.00	49.00	13.00	46.00
Beryllium	0.74	0.67	0.69	0.74	0.69	0.76	0.66	0.73
Cadmium	1.40	2.90	2.80	1.80	3.10	1.50	3.30	1.90
Chromium	18.00	17.00	18.00	17.00	18.00	19.00	17.00	18.00
Cobalt	12.00	11.00	11.00	15.00	9.20	10.00	13.00	11.00
Copper	27.00	26.00	23.00	49.00	21.00	23.00	32.00	27.00
Lead	14.00	13.00	14.00	23.00	10.00	13.00	16.00	16.00
Mercury	ND	ND	ND	ND	ND	0.10	ND	ND
Nickel	30.00	29.00	28.00	41.00	25.00	27.00	34.00	31.00
Thallium	ND	ND	ND	ND	ND	ND	ND	ND
Tin	31.00	33.00	31.00	28.00	35.00	29.00	33.00	30.00
Vanadium	24.00	22.00	23.00	25.00	21.00	24.00	22.00	23.00
Zinc	48.00	54.00	46.00	58.00	45.00	48.00	63.00	56.00
Sample Depth (feet)	25-27	20-22	20-22	20-24	22-24	22-24	20-22	27-29

ND - Nondetect
Sample depth - feet below grade
All concentrations in mg/kg

cwm\4-11

TABLE 4-13
CLAY PHASE II METALS
INTERMEDIATE

METALS	C-1	C-2	C-2R	C-3	C-4	C-5	C-6	C-7
Antimony	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	2.90	15.00	13.00	13.00	16.00	18.00	16.00	12.00
Barium	55.00	11.00	14.00	37.00	13.00	16.00	12.00	23.00
Beryllium	0.87	0.44	0.35	0.74	0.38	0.61	0.41	0.58
Cadmium	1.50	3.54	2.90	2.00	3.40	2.00	3.70	1.80
Chromium	23.00	9.30	7.70	17.00	8.60	11.00	8.60	16.00
Cobalt	13.00	13.00	11.00	15.00	13.00	13.00	12.00	15.00
Copper	25.00	50.00	37.00	42.00	42.00	44.00	46.00	40.00
Lead	13.00	20.00	21.00	24.00	24.00	22.00	23.00	24.00
Mercury	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	35.00	32.00	23.00	40.00	29.00	34.00	28.00	37.00
Thallium	ND	ND	ND	1.50	ND	1.70	ND	1.70
Tin	31.00	29.00	26.00	28.00	27.00	32.00	32.00	25.00
Vanadium	27.00	16.00	12.00	24.00	13.00	17.00	14.00	19.00
Zinc	56.00	90.00	53.00	100.00	50.00	64.00	81.00	66.00
Sample Depth (feet)	35-37	30-32	30-32	28-30	32-34	30-32	30-32	35-37

ND - Nondetect
Sample depth - feet below grade
All concentrations in mg/kg

cwm\4-12

TABLE 4-14
CLAY PHASE II METALS
DEEP

METALS	C-1	C-2R	C-3	C-4	C-5	C-6	C-7
Antimony	ND	ND	ND	ND	ND	ND	ND
Arsenic	11.00	11.00	9.40	11.00	10.00	11.00	8.90
Barium	21.00	15.00	21.00	27.00	25.00	23.00	33.00
Beryllium	0.58	0.46	0.56	0.63	0.58	0.57	0.72
Cadmium	1.90	7.10	1.80	3.40	1.90	3.40	1.80
Chromium	14.00	10.00	13.00	15.00	14.00	14.00	17.00
Cobalt	13.00	16.00	12.00	12.00	12.00	12.00	12.00
Copper	40.00	36.00	38.00	29.00	34.00	34.00	29.00
Lead	21.00	49.00	21.00	31.00	20.00	16.00	21.00
Mercury	ND	ND	ND	ND	ND	ND	ND
Nickel	31.00	41.00	32.00	31.00	31.00	30.00	30.00
Thallium	1.20	ND	ND	ND	ND	ND	1.20
Tin	28.00	35.00	27.00	32.00	27.00	33.00	28.00
Vanadium	18.00	17.00	17.00	19.00	18.00	18.00	21.00
Zinc	79.00	53.00	64.00	59.00	80.00	55.00	61.00
Sample Depth (feet)	59-61	54-56	52-54	56-58	54-58	54-56	59-61

ND - Nondetect
Sample depth - feet below grade
All concentrations in mg/kg

cwm\4-13

TABLE 4-15
CLAY PHASE I ORGANICS
LEVEL 1 *

Volatiles	B-304 C1	P-316 C1	G-318 C1	P-319 C1	P-322 C1	P-323 C1	B-328 C1	B-341 C1	B-346 C1
Acetone	0.021	0.019	0.024	0.017	10.3	0.022	0.013	0.022	0.022
Acetonitrile	0.044	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	ND	ND	ND	ND	ND	ND	ND	0.012	0.021
1,1 Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	0.006
1,1 Dichloroethylene	ND	ND	ND	ND	5.9	ND	ND	ND	ND
Ethyl methacrylate	ND	ND	0.202	ND	ND	ND	ND	ND	ND
2-hexanone	ND	ND	ND	ND	ND	ND	ND	ND	0.077
Methyl ethyl ketone	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	0.014	0.009	0.028	ND	114	0.025	0.020	0.093	0.111
Methyl-iso-butyl ketone	ND	ND	0.346	ND	ND	ND	ND	ND	0.200
1,1,1-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	ND	ND	ND	ND	128	ND	ND	ND	0.054
Toluene	ND	ND	ND	ND	ND	ND	ND	ND	0.025
Trichlorethylene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND
Semivolatiles									
Benzyl alcohol	1.98	ND	ND	1.95	ND	ND	ND	ND	ND
bis (2 Ethylhexyl) phthalate	ND	ND	ND	2.44	10.80	ND	2.09	ND	ND
Di-n-octyl phthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	ND	ND	ND	ND	0.37	ND	ND	ND	ND
Fluorene	ND	ND	ND	ND	ND	ND	ND	ND	ND
m+p Cresols	ND	ND	ND	ND	ND	ND	ND	ND	1.64
Napthalene	ND	ND	ND	ND	0.79	ND	ND	ND	ND
Phenanthrene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenol	ND	ND	ND	ND	7.53	ND	ND	ND	3.11
Pyrene	ND	ND	ND	ND	0.33	ND	ND	ND	ND
Sample Depth (feet)	18-20	21-23	18-20	19-21	18-20	14-16	16-18	14-16	14-16

* Data invalidated; see text.

ND - Nondetect
Sample depth - feet below grade
All concentrations in mg/kg

cwm\4-14

TABLE 4-16
CLAY PHASE I ORGANICS *
LEVEL 2

Volatiles	B-304 C2	P-316 C2	G-318 C2	P-319 C2	P-322 C2	P-323 C2	B-328 C2	B-341 C2	B-346 C2
Acetone	0.020	0.024	0.017	0.011	5.3	ND	0.021	0.021	0.024
Acetonitrile	ND	ND	0.031	ND	42.7	ND	ND	ND	ND
Benzene	ND	ND	ND	ND	4.0	ND	ND	0.012	ND
1,1 Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 Dichloroethylene	ND	ND	ND	ND	10.8	ND	ND	ND	ND
Ethyl methacrylate	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-hexanone	ND	ND	104	ND	ND	0.066	ND	ND	ND
Methyl ethyl ketone	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	0.011	0.008	0.016	0.013	113	0.099	0.026	0.015	0.152
Methyl-iso-butyl ketone	ND	ND	ND	ND	ND	0.036	ND	ND	0.164
1,1,1-Trichloroethane	ND	ND	ND	ND	178	ND	ND	ND	ND
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorethylene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND
Semivolatiles									
Benzyl alcohol	2.25	ND	ND	2.39	ND	ND	ND	ND	ND
bis (2 Ethylhexyl) phthalate	ND	ND	ND	ND	ND	1.75	ND	ND	ND
Di-n-octyl phthalate	ND	ND	ND	ND	ND	5.23	ND	ND	ND
Fluoranthene	ND	ND	ND	ND	0.81	ND	ND	ND	ND
Fluorene	ND	ND	ND	ND	0.40	ND	ND	ND	ND
m + p Cresols	ND	ND	ND	ND	ND	ND	ND	ND	ND
Napthalene	ND	ND	ND	ND	1.76	ND	ND	ND	ND
Phenanthrene	ND	ND	ND	ND	1.47	ND	ND	ND	ND
Phenol	ND	ND	ND	ND	3.17	ND	ND	ND	ND
Pyrene	ND	ND	ND	0.26	0.74	ND	ND	ND	ND
Sample Depth (feet)	26-28	28-31	26-31	26-29	28-30	22-27	22-24	22-24	24-26

* Data invalidated; see text.
ND - Nondetect
Sample depth - feet below grade
All concentrations in mg/kg

cwm4-15

TABLE 4-17
CLAY PHASE II ORGANICS
SHALLOW

Volatiles	C-1	C-2	C-2R	C-3	C-4	C-5	C-6	C-7
Acetone	ND	ND	ND	ND	ND	ND	ND	ND
Acetonitrile	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	ND	ND	ND	ND	ND	ND	ND	ND
1,1 Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND
1,1 Dichloroethylene	ND	ND	ND	ND	ND	ND	ND	ND
Ethyl methacrylate	ND	ND	ND	ND	ND	ND	ND	ND
2-hexanone	ND	ND	ND	ND	ND	ND	ND	ND
Methyl ethyl ketone	ND	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	ND	ND	ND	ND	ND	ND	ND	ND
Methyl-iso-butyl ketone	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorethylene	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	ND	ND	ND	ND	ND	ND	ND	ND
Semivolatiles								
Benzyl alcohol	ND	ND	ND	ND	ND	ND	ND	ND
bis(2 Ethylhexyl)phthalate	3.87	4.81	ND	6.14	41.5	6.64	ND	11
Di-n-octyl phthalate	2.62	6.08	4.3	1.9	6.91	3.98	4.66	3.97
Fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND
Fluorene	ND	ND	ND	ND	ND	ND	ND	ND
m+p Cresols	ND	ND	ND	ND	ND	ND	ND	ND
Napthalene	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	ND	ND	ND	ND	ND	ND	ND	ND
Phenol	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene	ND	ND	ND	ND	ND	ND	ND	ND
Sample Depth (feet)	25-27	20-22	20-22	20-24	22-24	22-24	20-22	27-29

ND - Nondetect

Sample depth - feet below grade

All concentrations in mg/kg

cwm\4-16

TABLE 4-18
CLAY PHASE II ORGANICS
INTERMEDIATE

Volatiles	C-1	C-2	C-2R	C-3	C-4	C-5	C-6	C-7
Acetone	ND	ND	0.461	ND	ND	ND	ND	ND
Acetonitrile	ND	ND	3.04	ND	ND	ND	ND	ND
Benzene	ND	ND	ND	ND	ND	ND	ND	ND
1,1 Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND
1,1 Dichloroethylene	ND	ND	ND	ND	ND	ND	ND	ND
Ethyl methacrylate	ND	ND	ND	ND	ND	ND	ND	ND
2-hexanone	ND	ND	ND	ND	ND	ND	ND	ND
Methyl ethyl ketone	ND	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	ND	ND	ND	ND	ND	ND	ND	ND
Methyl-iso-butyl ketone	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	ND	0.009	ND	ND	ND
Trichlorethylene	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	ND	ND	ND	0.013	ND	ND	ND	ND
Semivolatiles								
Benzyl alcohol	ND	ND	ND	ND	ND	ND	ND	ND
bis(2 Ethylhexyl)phthalate	7.69	9.41	ND	7.37	ND	4.12	ND	10.8
Di-n-octyl phthalate	4.35	6.58	2.67	17.6	4.09	8.51	2.28	4.25
Fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND
Fluorene	ND	ND	ND	ND	ND	ND	ND	ND
m+p Cresols	ND	ND	ND	ND	ND	ND	ND	ND
Napthalene	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	ND	ND	ND	ND	ND	ND	ND	ND
Phenol	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene	ND	ND	ND	ND	ND	ND	ND	ND
Sample Depth (feet)	35-37	30-32	30-32	28-30	32-34	30-32	30-32	35-37

ND - Nondetect
Sample depth - feet below grade
All concentrations in mg/kg

cwm/table.418

TABLE 4-19
CLAY PHASE II ORGANICS
DEEP

Volatiles	C-1	C-2R	C-3	C-4	C-5	C-6	C-7
Acetone	ND	ND	ND	ND	ND	ND	ND
Acetonitrile	ND	ND	ND	ND	ND	ND	ND
Benzene	ND	ND	ND	ND	ND	ND	ND
1,1 Dichloroethane	ND	ND	ND	ND	ND	ND	ND
1,1 Dichloroethylene	ND	ND	ND	ND	ND	ND	ND
Ethyl methacrylate	ND	ND	ND	ND	ND	ND	ND
2-hexanone	ND	ND	ND	ND	ND	ND	ND
Methyl ethyl ketone	ND	ND	ND	0.013	ND	ND	ND
Methylene chloride	ND	0.085	ND	ND	ND	ND	ND
Methyl-iso-butyl ketone	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	ND	ND	ND	ND
Trichlorethylene	ND	0.048	ND	ND	ND	ND	ND
Trichlorofluoromethane	ND	ND	0.021	ND	ND	0.019	ND
Semivolatiles							
Benzyl alcohol	ND	ND	ND	ND	ND	ND	ND
bis(2 Ethylhexyl)phthalate	7.75	ND	3.87	ND	4.45	ND	7.6
Di-n-octyl phthalate	3.07	5.81	12.0	4.46	15.2	2.02	14.9
Fluoranthene	ND	ND	ND	ND	ND	ND	ND
Fluorene	ND	ND	ND	ND	ND	ND	ND
m + p Cresols	ND	ND	ND	ND	ND	ND	ND
Napthalene	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	ND	ND	ND	ND	ND	ND	ND
Phenol	ND	ND	ND	ND	ND	ND	ND
Pyrene	ND	ND	ND	ND	ND	ND	ND
Sample Depth (feet)	59-61	54-56	52-54	56-58	54-58	54-56	59-61

ND - Nondetect
Sample depth - feet below grade
All concentrations in mg/kg

cwm/table.419

(8-inch) casing. The samples were collected with a split-spoon sampler, but extreme care was used to maintain the sample in its existing (dry) condition.

Phase I clay results yielded the greatest number of detections as well as highest concentrations of organic compounds in the biobed area. Other organic detections were measured in the high solids area, wastewater basin #2, and Hyon tank farm. However, these other areas did not yield the same levels nor quantity of detections.

Phase II clay results contradict the Phase I results. No organic compounds were detected in any clay samples collected 5 feet below the clay/fill contact, with the exception of phthalates, which are common laboratory artifacts. These samples were collected from the upper lacustrine unit, which has been shown to be a homogeneous, low permeability layer. However, low level VOC contaminants were measured in samples collected from the less plastic lower lacustrine layer (15 feet below the clay/fill contact) and the underlying clayey glacial till (40 feet below the clay/fill contact). These contaminant detection would preclude vertical migration as a cause.

Because fill and groundwater sampling show the biobed area to be the most extensively impacted area, the potential for cross-contamination in this area because of the Phase I sampling technique is apparent. Inspection of the Phase II data yield marked differences. No VOC detections were measured for any of the clay samples collected in areas outside the biobeds. Two semivolatile phthalate compounds were the only organic compounds measured in the clay samples collected from these areas. VOC compounds were restricted to samples collected from the biobed area. Unlike Phase I, only seven VOC compounds were measured in the Phase II biobed clay samples. In addition, the same two phthalates were detected in these borings. Phthalate compounds were detected in only a few groundwater and fill samples. Research on phthalates indicates that the source of these compounds may be from outside the environment (laboratory, sampling procedures, etc.).

Three of the seven VOC contaminants, acetone, methylene chloride and trichlorofluoromethane, are common laboratory artifacts. A fourth, methyl ethyl ketone, like acetone, is a ketone that may be derived from laboratory contamination. The other three compounds include acetonitrile, toluene and trichloroethylene. Only acetonitrile was measured at significant levels (> 3 mg/kg); the other two compounds were measured slightly above the detection limit. It should also be noted that acetonitrile is used as an extraction compound in the analysis of certain phthalates.

Metals were common in samples collected during both Phase I and Phase II. However, the preponderance of metals throughout the subsurface at this site has been previously shown. Metals are not readily mobile, and may be naturally occurring at these concentrations. Concentrations are similar between Level 1 and Level 2. Groundwater and soil contamination appears to be limited to the fill material.

In general, the lack of contaminants in the Phase II samples indicates the upper lacustrine layer presently provides a barrier to the migration of contaminants. Hydrogeologic data presented in Part 1, Section 2.0 of this report supports this conclusion. The low concentrations measured in the Phase II samples compared to the Phase I samples, and the occurrence of common laboratory artifacts, indicates the measured contamination in Phase II is suspect. Summarily, these measurements indicate that clay deposits are not significantly contaminated.

4.3.2 Fill Results

Soil samples of the fill material were collected during both phases of the investigation. These samples were analyzed for priority pollutants common to Appendix IX. Laboratory results are included in Appendix K.

Fill sample locations and sample horizons differed between Phase I and Phase II. Sample locations for each SWMU by matrix are shown on Table 4-1. A description of the sample locations and horizons follows.

Sample Location

Phase I fill samples were collected from 49 locations. These include 24 borings in which RFI wells were installed. Additional samples were collected at boring locations strategically located across the property. Boring locations and RFI well locations are shown on Figure 1-2. Phase II fill samples were collected at 17 locations. All borings were advanced in the SWMUs.

Sample Horizons

Both Phase I and II fill samples were collected at two horizons to determine the vertical extent of contamination. The shallow horizon is referred to as Level 1 and the deeper horizon as Level 2. Laboratory sample results are presented with an F1 or F2 behind the appropriate boring location. Phase II fill samples were also collected at shallow and deep horizons. Laboratory sample results are presented with an S or D behind the appropriate boring location. Metals detected in samples collected from both horizons during the investigation are summarized in Tables 4-20 through 4-23. The sum of organic constituents by chemical groups are presented in Tables 4-24 through 4-27. (Organic chemical groups are the same as presented in Table 4-6.)

In addition to the soil samples of the fill material collected from borings, surface soil samples were also collected. These samples were collected during Phase II, as part of the risk assessment. Laboratory results have been included in Appendix K. Detected constituents are summarized in Tables 4-28 and 4-29.

TABLE 4-20
FILL PHASE I METALS LEVEL 1

	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Zinc
B-301F1	ND	3.60	0.70	2.90	14.00	24.00	220.00	0.12	12.00	ND	3.50	ND	352.00
B-304F1	ND	6.70	0.61	1.40	18.00	29.00	18.00	0.15	31.00	ND	1.40	ND	46.00
B-306F1	ND	68.00	2.10	1.30	41.00	22.00	22.00	ND	19.00	4.40	ND	3.50	150.00
B-309F1	15.00	ND	0.40	ND	180.00	28.00	86.00	0.10	23.00	ND	ND	ND	160.00
B-310F1	8.10	8.50	0.39	0.66	14.00	58.00	190.00	0.44	24.00	ND	ND	ND	160.00
B-311F1	9.60	37.00	0.36	ND	11.00	129.00	140.00	1.10	17.00	ND	ND	ND	110.00
B-312F1	ND	16.00	0.68	ND	19.00	44.00	79.00	0.18	32.00	ND	ND	ND	110.00
B-313F1	9.30	6.30	0.77	ND	13.00	32.00	95.00	0.16	20.00	ND	ND	ND	140.00
B-315F1	8.50	67.00	1.80	2.10	43.00	28.00	33.00	ND	20.00	4.20	ND	3.80	210.00
B-320F1	ND	12.00	0.57	2.10	18.00	34.00	33.00	0.40	30.00	ND	2.70	ND	100.00
B-321F1	9.30	18.00	0.43	ND	15.00	27.00	25.00	0.15	25.00	ND	ND	ND	73.00
B-325F1	11.00	5.50	0.69	0.26	50.00	42.00	280.00	0.23	21.00	ND	ND	ND	268.00
B-326F1	ND	7.00	0.33	ND	49.00	20.00	90.00	0.14	10.00	ND	ND	ND	110.00
B-327F1	13.00	5.70	0.43	ND	16.00	30.00	33.00	0.12	30.00	ND	ND	ND	60.00
B-328F1	ND	3.70	0.33	ND	14.00	31.00	32.00	ND	34.00	ND	ND	ND	71.00
B-331F1	ND	6.40	0.41	4.00	14.00	33.00	330.00	0.39	13.00	ND	ND	ND	170.00
B-333F1	18.00	9.90	0.81	0.59	61.00	51.00	130.00	0.28	33.00	ND	ND	ND	244.00
B-335F1	ND	24.00	0.81	2.10	17.00	74.00	500.00	0.84	21.00	ND	2.40	2.10	371.00
B-338F1	9.30	8.00	0.34	ND	13.00	35.00	53.00	0.23	27.00	ND	ND	ND	120.00
B-339F1	20.00	ND	2.30	1.70	41.00	26.00	55.00	0.14	22.00	2.50	ND	ND	230.00

TABLE 4-20
FILL PHASE I METALS LEVEL 1

	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Zinc
B-340F1	12.00	31.00	2.00	4.30	51.00	34.00	41.00	0.14	30.00	ND	1.90	ND	210.00
B-341F1	21.00	27.00	2.00	4.20	58.00	133.00	470.00	0.49	25.00	2.10	ND	1.50	ND
B-345F1	11.00	19.00	3.00	6.60	76.00	47.00	57.00	ND	40.00	1.70	3.70	1.70	ND
B-346F1	29.00	27.00	2.30	1.60	68.00	33.00	51.00	0.12	38.00	2.70	ND	2.30	ND
G-303F1	ND	4.20	0.45	1.30	8.10	18.00	95.00	0.12	6.80	ND	1.70	ND	69.00
G-305F1	ND	7.80	0.30	ND	9.40	26.00	31.00	ND	18.00	ND	ND	ND	59.00
G-307F1	9.30	5.90	0.16	0.33	9.50	9.80	29.00	ND	6.70	ND	ND	ND	52.00
G-308F1	ND	9.10	0.65	3.00	14.00	63.00	130.00	0.25	34.00	ND	2.00	ND	130.00
G-314F1	17.00	8.60	0.58	ND	79.00	44.00	73.00	ND	37.00	ND	ND	ND	190.00
G-317F1	ND	2.40	ND	34.50	1400.00	46.00	35.00	ND	7.20	ND	10.00	ND	41.00
G-318F1	7.30	5.20	0.51	1.50	41.00	21.00	11.00	ND	23.00	ND	2.00	ND	50.00
G-324F1	11.00	19.00	0.56	2.50	18.00	58.00	180.00	0.30	21.00	ND	2.00	ND	180.00
G-324F1	ND	12.00	0.75	4.30	72.00	48.00	190.00	0.24	27.00	ND	1.90	ND	160.00
G-330F1	ND	12.00	0.64	1.60	23.00	38.00	130.00	0.14	24.00	ND	1.80	ND	110.00
G-332F1	ND	5.70	0.83	ND	54.00	56.00	92.00	ND	30.00	ND	ND	ND	160.00
G-334F1	ND	2.70	ND	0.80	5.00	6.90	ND	ND	6.10	ND	ND	ND	34.00
G-336F1	ND	10.00	0.39	3.00	8.40	36.00	310.00	0.14	6.90	ND	3.70	ND	85.00
G-337F1	ND	6.00	0.64	2.20	16.00	36.00	120.00	0.19	25.00	ND	2.80	ND	150.00
G-342F1	11.00	ND	0.49	ND	23.00	44.00	58.00	0.11	24.00	ND	ND	ND	130.00
G-343F1	ND	4.20	0.21	1.20	6.80	14.00	74.00	0.10	6.50	ND	1.90	ND	54.00
G-344F1	ND	15.00	2.20	6.10	38.00	50.00	130.00	0.16	19.00	ND	2.70	1.70	239.00

TABLE 4-20
FILL PHASE I METALS LEVEL 1

	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Zinc
G-347F1	9.20	7.50	0.26	ND	10.00	25.00	24.00	ND	23.00	ND	ND	ND	52.00
G-348F1	ND	1.90	ND	ND	4.20	5.10	9.50	ND	5.30	ND	ND	ND	29.00
G-349F1	ND	ND	1.60	0.87	60.00	22.00	75.00	0.16	28.00	ND	ND	ND	210.00
P-316F1	10.00	1.50	0.20	1.30	552.00	25.00	12.00	ND	9.00	ND	4.70	ND	15.00
P-319F1	ND	5.60	0.68	2.00	20.00	35.00	20.00	ND	32.00	ND	2.30	ND	65.00
P-322F1	ND	560.00	1.10	ND	23.00	48.00	85.00	6.50	29.00	ND	ND	1.60	110.00
P-323F1	ND	22.00	2.30	4.30	46.00	21.00	46.00	0.13	17.00	6.90	ND	2.60	260.00
P-329F1	ND	11.00	0.34	ND	11.00	42.00	130.00	ND	25.00	ND	ND	ND	120.00

ND - Nondetect
All concentrations are in mg/kg

cwm/table.420

TABLE 4-21
FILL PHASE I METALS LEVEL 2

	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Zinc
B-301F2	17.00	10.00	0.59	ND	17.00	32.00	48.00	0.11	25.00	ND	ND	ND	85.00
B-304F2	9.10	17.00	0.86	2.40	29.00	44.00	120.00	0.16	36.00	ND	1.80	ND	240.00
B-306F2	13.00	7.90	0.44	ND	16.00	16.00	ND	ND	24.00	ND	ND	ND	49.00
B-309F2	13.00	7.10	0.48	ND	18.00	28.00	13.00	ND	29.00	ND	ND	ND	53.00
B-310F2	11.00	6.80	0.50	ND	18.00	30.00	36.00	ND	31.00	ND	ND	ND	66.00
B-311F2	10.00	27.00	0.38	ND	12.00	35.00	75.00	0.87	22.00	ND	ND	ND	83.00
B-312F2	ND	8.00	0.46	ND	15.00	26.00	17.00	ND	28.00	ND	ND	ND	54.00
B-313F2	8.20	9.20	0.63	ND	19.00	20.00	25.00	ND	25.00	ND	ND	ND	58.00
B-315F2	ND	18.00	1.00	0.89	25.00	16.00	30.00	ND	16.00	ND	ND	ND	130.00
B-320F2	12.00	10.00	0.59	ND	19.00	37.00	36.00	0.13	36.00	ND	ND	ND	120.00
B-321F2	9.30	9.00	0.34	ND	14.00	21.00	14.00	ND	24.00	ND	ND	ND	53.00
B-325F2	7.80	5.80	0.51	ND	32.00	82.00	76.00	ND	28.00	ND	ND	ND	230.00
B-326F2	ND	5.40	0.27	ND	11.00	21.00	25.00	ND	20.00	ND	ND	ND	40.00
B-327F2	9.90	6.50	0.45	ND	16.00	34.00	100.00	0.16	24.00	ND	ND	ND	98.00
B-328F2	ND	5.90	0.35	ND	13.00	30.00	32.00	ND	31.00	ND	ND	ND	48.00
B-331F2	ND	ND	0.41	ND	12.00	46.00	360.00	0.53	16.00	ND	ND	ND	311.00
B-333F2	ND	8.00	0.52	ND	16.00	13.00	77.00	ND	13.00	ND	ND	ND	99.00
B-335F2	ND	20.00	0.60	0.96	18.00	53.00	180.00	0.37	16.00	ND	1.60	1.50	150.00
B-338F2	12.00	6.60	0.51	ND	19.00	32.00	30.00	ND	34.00	ND	ND	ND	63.00
B-339F2	19.00	13.00	2.30	1.00	37.00	29.00	62.00	ND	30.00	1.90	ND	ND	190.00
B-340F2	ND	25.00	1.40	3.80	45.00	32.00	49.00	0.13	18.00	3.30	3.10	ND	190.00

TABLE 4-21
FILL PHASE I METALS LEVEL 2

	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Zinc
B-341F2	22.00	26.00	2.00	4.00	52.00	26.00	360.00	0.14	34.00	ND	ND	2.50	656.00
B-345F2	30.00	31.00	2.60	3.60	79.00	31.00	46.00	ND	44.00	4.20	ND	3.80	476.00
B-346F2	20.00	15.00	1.60	2.50	43.00	20.00	37.00	0.18	24.00	2.20	ND	1.50	252.00
G-302F2	12.00	9.70	0.43	ND	14.00	35.00	23.00	ND	28.00	ND	ND	ND	51.00
G-303F2	ND	9.60	0.50	1.60	17.00	32.00	30.00	ND	27.00	ND	1.70	ND	89.00
G-305F2	ND	3.50	0.45	ND	16.00	17.00	12.00	ND	26.00	ND	ND	ND	48.00
G-307F2	ND	6.50	0.18	ND	8.30	11.00	11.00	ND	12.00	ND	ND	ND	39.00
G-308F2	ND	9.70	0.85	4.60	20.00	49.00	100.00	0.14	29.00	ND	1.70	ND	110.00
G-314F2	8.00	17.00	0.17	ND	11.00	14.00	36.00	ND	17.00	ND	ND	ND	130.00
G-317F2	45.00	4.10	0.22	7.70	1110.00	47.00	72.00	0.15	14.00	ND	9.50	ND	99.00
G-318F2	ND	11.00	0.64	2.00	23.00	29.00	95.00	0.14	27.00	ND	2.70	ND	74.00
G-324F2	8.70	6.40	0.47	3.90	179.00	25.00	290.00	0.18	8.40	ND	4.80	ND	120.00
G324F2	ND	14.00	0.84	5.00	19.00	45.00	39.00	0.13	36.00	ND	1.80	1.30	76.00
G-330F2	ND	7.80	0.88	1.80	56.00	38.00	56.00	0.12	20.00	ND	1.50	ND	120.00
G-332F2	ND	4.40	0.73	ND	25.00	22.00	53.00	ND	21.00	ND	ND	ND	270.00
G-334F2	11.00	6.20	0.36	ND	14.00	16.00	11.00	ND	21.00	ND	ND	ND	47.00
G-336F2	7.40	4.20	0.43	2.80	10.00	34.00	38.00	ND	13.00	ND	3.50	ND	60.00
G-337F2	8.20	7.10	0.56	1.80	15.00	34.00	18.00	ND	31.00	ND	1.90	ND	52.00
G-342F2	33.00	30.00	2.20	1.30	55.00	46.00	52.00	0.12	28.00	4.80	ND	2.30	329.00
G-343F2	ND	3.00	0.13	0.91	5.60	7.80	32.00	ND	4.60	ND	1.50	ND	31.00
G-344F2	ND	21.00	2.20	5.80	39.00	31.00	68.00	ND	20.00	3.30	1.60	1.80	190.00

TABLE 4-21 FILL PHASE I METALS LEVEL 2													
	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Zinc
G-347F2	ND	3.70	ND	ND	3.40	4.80	55.00	ND	4.00	ND	ND	ND	38.00
G-348F2	20.00	31.00	3.00	6.30	52.00	21.00	89.00	ND	22.00	3.80	ND	3.40	428.00
G-349F2	14.00	30.00	2.00	2.20	47.00	22.00	32.00	ND	27.00	2.70	ND	3.10	250.00
P-316F2	ND	4.40	0.49	1.70	31.00	42.00	160.00	0.29	16.00	ND	2.40	ND	220.00
P-319F2	9.00	11.00	0.57	1.70	22.00	40.00	470.00	0.16	15.00	ND	1.90	ND	250.00
P-322F2	ND	24.00	0.24	ND	10.00	13.00	16.00	0.11	14.00	ND	ND	ND	35.00
P-323F2	9.30	6.50	0.16	ND	5.50	8.40	ND	ND	9.60	ND	ND	ND	40.00
P-329F2	ND	9.20	0.49	ND	14.00	56.00	220.00	0.10	28.00	ND	ND	ND	230.00

ND - Nondetect
All concentrations are in mg/kg

cwm/table.421

TABLE 4-22
FILL PHASE II METALS SHALLOW

	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Zinc
FG-1S	ND	7.6	0.7	1.8	18	27	69	0.11	18	ND	ND	ND	98
FG-2S	ND	76	0.76	2.8	35	38	75	3.1	32	ND	ND	ND	120
FG-3S	7.6	48	0.64	3.1	14	55	150	3.8	23	ND	ND	ND	98
FG-4S	ND	9.6	0.76	2.5	20	40	76	0.11	28	ND	ND	ND	120
FG-5S	ND	30	3.1	7.7	55	29	120	ND	25	2.9	ND	3.7	308
FG-6S	ND	13	3	4.9	29	23	39	ND	20	2.4	ND	ND	190
FG-7S	ND	29	2.5	5	453	110	390	0.59	47	8.2	1.3	ND	1410
FG-8S	ND	193	0.99	2.6	45	90	110	0.19	34	ND	ND	3.2	160
FG-9S	ND	4.8	2	2.4	41	53	48	0.22	32	ND	ND	ND	74
FG-10S	ND	ND	1	2.5	31	32	38	ND	31	ND	ND	ND	79
FG-11S	ND	6.3	0.79	2.8	18	46	74	0.1	17	ND	ND	ND	140
FG-12S	ND	2.1	0.66	0.87	7.4	7.3	22	ND	4.1	ND	ND	ND	21
FG-13S	ND	2.4	0.48	0.8	11	8	29	ND	7.1	ND	ND	ND	42
FG-14S	ND	25	2.9	9.2	66	30	39	ND	33	4.5	ND	2.5	369
FG-15S	ND	1.7	2.1	21	798	48	43	ND	13	ND	3	ND	54
FG-16S	ND	10	0.87	2.4	15	35	130	0.1	14	ND	ND	ND	120
FG-17S	ND	4.8	0.62	1.9	18	136	530	ND	15	ND	ND	ND	277

ND - Nondetect
All concentrations are in mg/kg

cwm/table.422

TABLE 4-23 FILL PHASE II METALS DEEP													
	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Zinc
FG-1D	ND	7.9	1.1	2.9	19	29	90	0.19	17	ND	ND	ND	266
FG-2D	9.4	46	0.69	2.8	16	44	180	1.1	18	ND	ND	ND	190
FG-3D	ND	24	1	3.1	27	41	100	0.56	27	ND	ND	ND	130
FG-4D	ND	5.6	0.87	2.3	21	26	19	ND	30	ND	ND	ND	65
FG-5D	ND	23	2	5.7	45	51	120	0.14	21	3.1	ND	2.5	262
FG-6D	ND	17	2.6	7.1	43	34	88	0.18	23	2.2	ND	2.4	240
FG-7D	ND	16	0.62	2.4	13	71	110	0.19	20	ND	ND	ND	160
FG-8D	ND	33	0.56	2	14	43	190	0.24	15	ND	ND	ND	210
FG-9D	ND	6.5	0.63	1.6	14	20	91	0.22	11	ND	ND	ND	87
FG-10D	ND	11	0.68	1.8	15	34	310	0.35	14	ND	ND	ND	160
FG-11D	ND	26	2.3	9.1	62	35	62	ND	36	2.6	ND	3	341
FG-12D	ND	4.1	1.2	3.3	36	17	24	ND	15	ND	ND	ND	77
FG-13D	ND	5.6	1.2	2.5	27	18	55	ND	21	0.82	ND	ND	100
FG-14D	ND	18	1.1	4.2	25	33	100	0.16	34	1.7	ND	1.8	130
FG-15D	ND	3.4	0.66	3.2	141	26	30	ND	16	ND	ND	ND	64
FG-16D	ND	6.7	0.7	3.7	32	40	130	0.11	29	ND	ND	ND	120
FG-17D	ND	8.5	0.7	1.8	18	31	39	ND	31	ND	ND	ND	59

ND - Nondetect
All concentrations are in mg/kg

cwm/table.423

TABLE 4-24 FILL PHASE I ORGANICS BY CHEMICAL GROUPS LEVEL 1					
LOCATION	AROMATICS	HALOGENATED		PHENOLS	PAH
		AROMATICS	HYDROCARBONS		
B-301F1	ND	0.06	0.73	ND	7.43
B-304F1	ND	ND	0.08	ND	2.78
B-306F1	ND	ND	67.54	15.84	ND
B-309F1	78.13	0.02	180.41	34.93	22.41
B-310F1	ND	ND	0.13	ND	339.98
B-311F1	35.19	767.00	5.09	ND	39.99
B-312F1	ND	1.37	0.18	ND	13.40
B-313F1	0.08	0.08	0.14	1.12	32.34
B-315F1	ND	ND	0.11	ND	ND
B-320F1	ND	ND	0.03	0.73	24.92
B-325F1	0.01	ND	0.12	ND	39.88
B-327F1	0.01	ND	0.07	0.77	12.05
B-328F1	ND	ND	0.05	ND	16.43
B-331F1	ND	ND	51.25	56.50	149.60
B-333F1	1.32	ND	0.17	6.09	95.03
B-335F1	ND	ND	0.05	ND	621.31
B-338F1	0.01	ND	0.40	ND	ND
B-339F1	ND	ND	0.05	ND	22.19
B-340F1	ND	ND	0.03	32.60	2.87
B-341F1	12.70	ND	0.08	ND	161.16
B-345F1	0.22	0.84	0.07	52.49	ND
B-346F1	1.49	0.32	0.10	8.79	ND
B-321F1	ND	ND	0.08	4.65	57.61
B-326F1	0.01	ND	0.06	ND	115.95
G-302F1	ND	ND	ND	ND	ND
G-303F1	ND	ND	0.04	ND	172.68
G-305F1	0.40	ND	0.65	ND	3.51
G-307F1	ND	ND	0.19	ND	1.67
G-308F1	ND	ND	0.02	ND	336.90
G-314F1	0.02	ND	0.08	0.84	17.93
G-317F1	ND	ND	0.01	ND	ND

TABLE 4-24 FILL PHASE I ORGANICS BY CHEMICAL GROUPS LEVEL 1					
LOCATION	AROMATICS	HALOGENATED		PHENOLS	PAH
		AROMATICS	HYDROCARBONS		
G-318F1	0.01	ND	0.08	ND	ND
G-324F1	0.01	0.01	0.04	ND	549.39
G-330F1	ND	ND	0.64	ND	ND
G-332F1	ND	ND	0.34	29.39	34.69
G-334F1	ND	ND	0.08	ND	48.18
G-336F1	0.04	0.02	0.03	ND	ND
G-337F1	ND	ND	0.03	ND	ND
G-342F1	ND	1.08	0.92	ND	15.28
G-343F1	ND	ND	0.02	ND	3.69
G-344F1	ND	ND	0.02	ND	1.70
G-347F1	ND	ND	0.03	ND	ND
G-348F1	ND	8.73	0.04	1.93	ND
G-349F1	ND	2.02	1.18	1.45	1.11
P-316F1	0.16	ND	0.07	ND	ND
P-319F1	1.78	0.41	1.41	ND	0.77
P-322F1	1.21	0.93	741.88	34.44	70.37
P-323F1	0.01	ND	0.27	ND	225.56
P-329F1	ND	ND	0.50	ND	5.39

ND - Nondetect
All concentrations are in mg/kg

cwm\table.424

TABLE 4-25
FILL PHASE I ORGANICS BY CHEMICAL GROUPS LEVEL 2

LOCATION	AROMATICS	HALOGENATED		PHENOLS	PAH
		AROMATICS	HYDROCARBONS		
B-301F2	0.007	ND	0.948	ND	1.311
B-304F2	0.029	ND	0.027	ND	17.335
B-306F2	ND	ND	10.670	ND	ND
B-309F2	0.014	ND	0.168	ND	ND
B-310F2	ND	ND	0.058	ND	7.865
B-311F2	0.006	0.012	0.036	ND	1.602
B-312F2	ND	ND	0.248	ND	2.178
B-313F2	0.006	ND	0.385	ND	3.013
B-315F2	ND	ND	0.205	ND	ND
B-320F2	ND	ND	0.018	0.561	46.625
B-325F2	0.005	ND	0.090	0.669	17.305
B-327F2	ND	ND	0.033	0.503	9.629
B-328F2	0.005	ND	0.347	ND	6.131
B-331F2	ND	ND	76.700	18.600	1241.100
B-333F2	0.049	ND	0.077	2.090	43.450
B-335F2	ND	ND	0.149	ND	17.190
B-338F2	ND	ND	0.026	ND	32.320
B-339F2	ND	ND	0.084	ND	3.157
B-340F2	ND	ND	0.699	7.060	10.160
B-341F2	0.250	ND	0.118	ND	11.238
B-345F2	0.013	ND	0.019	7.300	ND
B-346F2	ND	ND	0.009	1.680	0.887
B-321F2	ND	ND	0.031	ND	4.098
B-326F2	ND	ND	0.055	1.020	2.485
G-302F2	ND	ND	2.470	0.825	ND
G-303F2	ND	ND	0.046	ND	0.804
G-305F2	ND	ND	0.343	ND	ND

TABLE 4-25
FILL PHASE I ORGANICS BY CHEMICAL GROUPS LEVEL 2

LOCATION	HALOGENATED				
	AROMATICS	AROMATICS	HYDROCARBONS	PHENOLS	PAH
G-307F2	ND	ND	0.133	ND	ND
G-308F2	ND	ND	0.022	ND	110.120
G-314F2	0.082	ND	1.078	1.610	8.457
G-317F2	0.021	ND	0.023	ND	ND
G-318F2	ND	ND	0.032	ND	15.544
G-324F2	ND	ND	0.020	ND	58.612
G-330F2	0.115	ND	1.078	0.358	39.584
G-332F2	2.336	0.336	2.980	ND	13.619
G-334F2	ND	ND	0.022	ND	ND
G-336F2	0.008	ND	0.012	ND	ND
G-337F2	ND	ND	1.060	ND	0.874
G-342F2	0.010	ND	0.083	58.233	16.764
G-343F2	ND	ND	0.021	ND	0.721
G-344F2	0.357	0.013	0.054	3.620	4.840
G-347F2	ND	ND	0.016	ND	2.312
G-348F2	0.274	0.016	0.031	ND	1.243
G-349F2	4.664	ND	0.874	ND	3.140
P-316F2	0.038	0.023	0.023	ND	35.200
P-319F2	0.339	0.268	0.136	ND	31.780
P-322F2	8.750	ND	1384.750	17.840	57.530
P-323F2	0.012	ND	0.482	ND	ND
P-329F2	ND	ND	0.184	ND	31.921

ND - Nondetect
All concentrations are in mg/kg

cwm\table.425

TABLE 4-26 FILL PHASE II ORGANICS BY CHEMICAL GROUPS SHALLOW					
		HALOGENATED			
LOCATION	AROMATICS	AROMATICS	HYDROCARBONS	PHENOLS	PAH
FG-1S	ND	ND	2.566	ND	51.520
FG-2S	ND	ND	0.076	ND	24.836
FG-3S	ND	ND	0.012	ND	25.762
FG-4S	0.006	ND	0.054	ND	46.809
FG-5S	2.287	0.462	4.850	9.680	6.480
FG-6S	1.214	ND	0.015	0.900	64.080
FG-7S	3.884	ND	3.728	11.524	ND
FG-8S	3.200	ND	2.026	1.679	35.811
FG-9S	21.470	0.349	501.720	71.432	38.373
FG-10S	ND	ND	0.004	ND	ND
FG-11S	ND	ND	ND	ND	ND
FG-12S	ND	ND	ND	0.435	ND
FG-13S	11.180	8.930	ND	75.950	ND
FG-14S	0.272	ND	ND	ND	3.830
FG-15S	0.375	ND	0.832	ND	0.896
FG-16S	0.015	ND	ND	ND	3.020
FG-17S	3.237	ND	5.229	12.670	83.580

ND - Nondetect
All concentrations are in mg/kg

cwm/table.426

TABLE 4-27 FILL PHASE II ORGANICS BY CHEMICAL GROUPS DEEP					
LOCATION	AROMATICS	HALOGENATED		PHENOLS	PAH
		AROMATICS	HYDROCARBONS		
FG-1D	ND	ND	0.027	0.217	41.530
FG-2D	0.101	0.024	2.118	0.469	24.701
FG-3D	ND	ND	ND	ND	51.260
FG-4D	ND	ND	0.028	ND	0.602
FG-5D	1.919	ND	1.560	12.200	57.200
FG-6D	0.008	ND	0.014	0.504	25.844
FG-7D	1.328	ND	1.163	1.750	25.273
FG-8D	0.189	0.014	0.397	ND	3.991
FG-9D	9.610	ND	137.360	ND	22.940
FG-10D	ND	ND	ND	ND	28.574
FG-11D	2.280	0.235	ND	3.953	0.442
FG-12D	0.632	ND	0.045	3.180	64.840
FG-13D	5.776	3.740	1.002	44.400	3.740
FG-14D	5.651	ND	0.476	ND	32.070
FG-15D	6.250	ND	ND	2.890	2.510
FG-16D	1.615	ND	ND	ND	9.670
FG-17D	0.137	ND	2.188	ND	12.640

ND - Nondetect
All concentrations are in mg/kg

cwm\table.427

TABLE 4-28
SURFACE SEDIMENT PHASE II METALS

	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc
SS1	ND	5.9	1.2	4	110	43	120	0.12	20	1.2	251
SS2	ND	ND	2	13	968	32	39	0.11	12	3.5	67
SS3	23	2.6	1.3	12	1060	36	43	ND	26	3.3	81
SS4	ND	ND	1.6	12	1320	52	32	ND	12	3	67
SS5	22	2.5	1.3	12	740	44	92	0.11	14	2.4	110
SS6	9.5	7.2	1.5	4.7	184	49	260	0.15	24	ND	481
SS7	ND	30	0.99	4.2	92	60	200	0.26	32	ND	220
SS8	ND	5.1	0.71	2.5	34	34	120	0.16	19	ND	150
SS9	ND	15	0.85	3.4	44	67	140	0.23	33	ND	514
SS10	ND	5.4	1.9	1.7	27	23	44	0.11	17	ND	81
SS11	ND	23	0.54	2.7	32	48	240	0.77	24	ND	170
SS12	ND	5.6	0.54	2.9	17	43	130	0.37	11	ND	230
SS13	ND	4.2	0.50	3.2	14	46	160	0.26	18	ND	220
SS14	19	2.1	1.3	12	864	38	48	0.12	11	2.7	92
SS15	22	ND	1.4	10	1060	35	41	0.12	140	3.4	100
SS16	ND	ND	1.5	55.7	600	78	68	ND	71	3.7	110
SS17	ND	3.7	3.4	3.8	126	43	100	0.15	17	ND	220
SS18	9.1	22	2	12	803	44	66	0.44	13	2.3	130
SS19	ND	18	0.86	3.3	42	54	290	0.54	26	ND	293
SS20	ND	4.4	0.36	1.5	8.9	15	11	ND	15	ND	40
SS21	ND	ND	0.27	0.54	29	16	45	0.25	7.5	ND	82
SS22	90	4.3	0.69	5	157	54	1260	0.13	11	ND	1570
SS23	ND	9.6	2	4.3	57	32	270	0.23	13	ND	744

ND - Nondetect

cwm\table.428

TABLE 4-29
SURFACE SEDIMENT PHASE II
ORGANICS

	SS1	SS2	SS3	SS4	SS5	SS6	SS7	SS8	SS9	SS10	SS11
Benzo(a)anthracene	ND	ND	ND	ND	1.020	ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	ND	ND	0.305	0.463	0.998	ND	ND	ND	ND	ND	ND
Benzo(b)fluoranthene	ND	ND	0.606	0.916	1.240	ND	ND	ND	ND	ND	ND
Benzo(ghi)perylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(k)fluoranthene	ND	ND	0.314	0.386	0.762	ND	ND	ND	ND	ND	ND
Butyl benzyl phthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chrysene	ND	0.303	0.524	0.620	1.250	ND	ND	5.770	ND	ND	3.020
Di-n-butyl phthalate	ND	1.680	2.020	4.000	1.530	ND	ND	ND	ND	ND	ND
Fluoranthene	2.910	ND	0.833	0.804	1.960	4.120	ND	9.380	5.320	ND	4.510
Hexachlorobenzene	ND	ND	ND	ND	0.275	ND	ND	ND	ND	3.100	ND
Indeno(1,2,3-c,d)pyrene	ND	ND	ND	ND	0.529	ND	ND	ND	ND	ND	ND
Phenanthrene	ND	ND	1.330	ND	1.020	ND	ND	ND	ND	ND	ND
Pyrene	2.480	0.351	1.010	0.769	2.010	3.410	ND	7.750	4.520	ND	4.080
bis(2-Ethylhexyl)phthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethylene	ND	ND	0.019	ND	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Table 4-29 (Cont.)

	SS12	SS13	SS14	SS15	SS16	SS17	SS18	SS19	SS20	SS21	SS22	SS23
Benzo(a)anthracene	ND	ND	ND	ND	ND	1.040	ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	ND	ND	ND	ND	0.328	1.280	ND	ND	ND	ND	ND	ND
Benzo(b)fluoranthene	ND	ND	ND	ND	ND	2.450	ND	ND	ND	ND	ND	ND
Benzo(ghi)perylene	ND	ND	ND	ND	ND	0.792	ND	ND	ND	ND	ND	ND
Benzo(k)fluoranthene	ND	ND	ND	ND	ND	1.090	ND	ND	ND	ND	ND	ND
Butyl benzyl phthalate	ND	ND	6.830	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chrysene	ND	ND	ND	ND	0.374	1.230	ND	4.100	ND	ND	ND	ND
Di-n-butyl phthalate	ND	ND	ND	1.750	2.120	1.810	ND	ND	ND	ND	ND	ND
Fluoranthene	ND	3.240	0.354	ND	0.489	1.720	ND	7.870	ND	ND	5.070	6.070
Hexachlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Indeno(1,2,3-c,d)pyrene	ND	ND	ND	ND	ND	0.914	ND	ND	ND	ND	ND	ND
Phenanthrene	ND	ND	ND	ND	ND	1.010	ND	ND	ND	ND	ND	ND
Pyrene	ND	2.960	0.332	ND	0.425	1.560	ND	6.570	ND	ND	4.000	5.180
bis(2-Ethylhexyl)phthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	404.000	ND
1,1-Dichloroethylene	ND	ND	ND	0.014	ND	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	ND	0.016	ND	ND	0.011	ND	ND	0.004	ND	ND	ND	ND

ND - Nondetect
All concentrations in (mg/kg).

cwm\table.429

The contaminant distribution pattern of fill samples is a reflection of groundwater sample results. Inorganic constituents were not useful for determining the nature and extent of soil contamination. Concentrations of metals overall are higher in the fill than in the clay. No concentration gradients can be determined from sample results at different horizons. Concentrations of metals in the fill are likely the same as conditions prior to hazardous waste activities at the site.

Overall Phase I results better illustrate the contaminant distribution pattern. Phase I yielded a distinct distribution of contaminants based upon widespread sample locations. Phase II results confirmed that higher concentrations are found in the former SWMUs. To characterize the contaminant distribution pattern, six organic constituents and two metals were selected. Level 1 and Level 2 concentrations were similar. Isoconcentration maps showing concentrations of detected constituents in the fill and lake sediment samples were created. These maps have been included in Appendix L. Benzene, 1,1-dichloroethylene, phenol, 2,4-dichlorophenol, fluoranthene, pyrene, lead, and chromium were selected since these constituents were the most frequently occurring compounds in the fill.

The highest concentrations of benzene were detected in fill samples collected from the Biobeds area (SWMU #1), the former High Solids Basin (SWMU #4), and former Wastewater Basin #2 (SWMU #6). This was observed for both phases of fill samples. Significant concentrations of 1,1-dichloroethylene were detected in the Biobeds area (SWMU #1), the former High Solids Basin #2 (SWMU #4), and the former Wastewater Basin #2 (SWMU #6). Significant concentrations of phenols were detected in fill samples collected from SWMU #1, SWMU #4, SWMU #6, and the former Hyon Tank farm. 2,4-dichlorophenol was detected in fill samples collected from SWMU #1, SWMU #4, and the former Hyon Tank farm. These constituents clearly define SWMU #1, SWMU #4, SWMU #6, and the former Hyon Tank farm as areas of soil contamination.

Fluoranthene and pyrene were detected in numerous fill and lake sediment samples. Concentrations varied significantly. Some lake sediments yielded higher concentrations than fill samples, and vice versa. Consequently, the SWMUs previously identified as sources of soil contamination are not clearly defined. These isoconcentration maps do not indicate that the SWMUs are the sole source of contamination found in lake sediments. Other sources contributing to the contamination of lake sediments and lake sediment transport mechanisms are discussed in Section 4.4. Similarly, lead and chromium were detected in numerous fill and lake sediment samples, but do not clearly identify the SWMUs as the sole source of contamination.

These isoconcentration maps do indicate that the concentrations of benzene, 1,1-dichloroethylene, phenol, and 2,4-dichlorophenol decrease significantly away from the SWMUs. Groundwater and soil contaminant distribution patterns are similar. SWMU #1, SWMU #4, SWMU #6, and the former Hyon Tank farm all contain significant groundwater and soil contamination.

4.4 Surface Water and Sediment Analytical Results

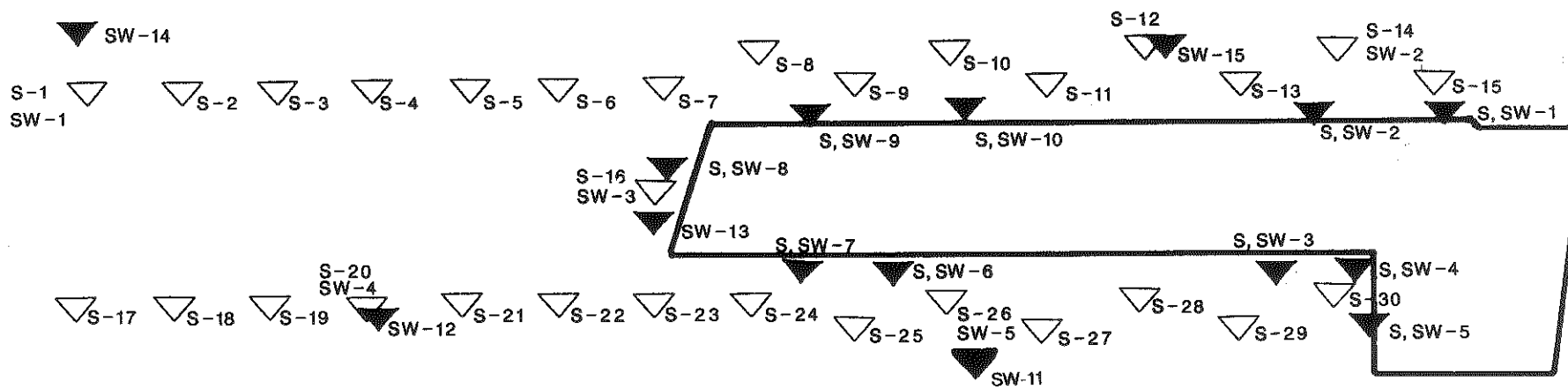
Surface water and sediment samples were collected from Lake Calumet during both phases of the investigation. These samples were collected to determine if potential releases from the CWMCS Facility have adversely impacted the sediments and surface water of Lake Calumet. Phase I sediment samples (S-1 to S-30) were collected along an east-west alignment extending into Lake Calumet. These samples were collected to determine a concentration gradient of lake sediments. Phase I surface water sediments were collected at five sediment sample locations along the same alignment, as shown on Figure 4-2.

Additional surface water and soil samples were collected during Phase II of the investigation. Samples S,SW-1 through S,SW-10 were collected around the perimeter of the pier. These

samples were collected to determine contaminant migration from the SWMUs located on the pier. (Sample locations and corresponding SWMUs are listed in Table 4-1). Five surface water samples (SW-11 through SW-15) were collected to determine Lake Calumet water quality at distant locations. Phase II sediment and surface water sample locations are shown on Figure 4-2. The Phase I sediment samples were analyzed for the Priority Pollutant List common to Appendix IX plus: chemical oxygen demand (COD), pH, ammonia nitrogen, nitrate + nitrite nitrogen, potassium, sodium, magnesium, calcium, and sulfate. (Sample S-6 was not analyzed due to insufficient sample volume.) Phase I surface water samples were analyzed for the Priority Pollutant List plus: total dissolved solids (TDS), total suspended solids (TSS), biological oxygen demand (BOD), chemical oxygen demand (COD), total alkalinity, total organic carbon (TOC), specific conductance, pH, ammonia nitrogen, nitrate + nitrite nitrogen, potassium, sodium, magnesium, calcium, and sulfate.

Phase II surface water and sediment samples were analyzed for priority pollutant metals, volatile organic compounds, and semi volatile organic compounds common to Appendix IX during the Phase II Investigation. Surface water results are presented on Tables 4-30 and 4-31. Sediment results are presented on Tables 4-32 through 4-36.





LEGEND

S-14, SW-2  PHASE I SEDIMENT SAMPLE (S) SURFACE WATER SAMPLE (SW)

S, SW-1  PHASE II SEDIMENT SAMPLE (S) SURFACE WATER SAMPLE (SW)

0 250 500 1000

APPROXIMATE SCALE: 1" = 500'

CWM CHEMICAL SERVICES INC.
CHICAGO INCINERATOR
RFI PHASE I AND PHASE II

FIGURE 4-2
Surface Water and Sediment Sample Locations

DRN. BY: MG

PROJ. NO.: 13963-052-29

DATE: JUNE 1992

DAMES & MOORE

TABLE 4-30
PHASE I SURFACE WATER RESULTS

PARAMETER (mg/l)	SW-1	SW-2	SW-3	SW-4	SW-5
Methylene Chloride	ND	0.003	0.003	ND	.0009
Alkalinity	120	140	120	120	120
Ammonia as N	2.8	2.0	0.48	0.29	0.34
BOD	4.0	4.0	2.0	2.0	2.0
Calcium	45.7	41.5	38.9	38.7	39.5
COD	24.0	34.0	12.0	< 10.0	< 10.0
Chloride	90.2	101.0	40.5	40.6	40.9
Cyanide, Total	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Magnesium	15.1	27.6	12.5	12.2	12.4
Nitrate + Nitrite	0.45	0.16	0.36	0.39	0.37
Phenolics, Total	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Potassium	4.8	14.0	2.8	2.7	3.0
Sodium	56.5	71.8	26.0	24.0	26.0
Total Suspended Solids	124	44.0	42.0	38.0	54.0
Sulfate as SO ₄	45.8	114	34.8	34.6	34.4
Total Dissolved Solids	300	430	220	200	220
Total Organic Carbon	7.40	13.1	3.5	4.4	3.6
pH (Field)	8.05	7.97	8.43	8.28	8.27
Specific Cond. (Field) umhos/cm	632	452	458	458	450
Temperature (Field) Deg. C.	15.3	13.6	12.7	14.2	14.5

ND - Nondetect

cwm\table.430

TABLE 4-31
PHASE II SURFACE WATER RESULTS

Sample Location	Mercury ($\mu\text{g/l}$)	pH	Specific Conductance (umhos/cm)	Temperature in Deg. C
SW-1	ND	8.17	813	15.5
SW-2	ND	8.20	799	9.6
SW-3	ND	8.05	559	8.2
SW-4	ND	8.05	536	5.9
SW-5	0.20	7.80	555	8.1
SW-6	ND	7.82	540	1.9
SW-7	ND	7.86	543	5.7
SW-8	ND	7.98	540	2.1
SW-9	ND	8.04	544	4.7
SW-10	ND	8.18	546	5.8
SW-11	ND	8.14	537	2.0
SW-12	ND	7.60	537	2.3
SW-13	ND	7.84	542	2.1
SW-14	ND	7.85	540	1.8
SW-15	ND	8.17	798	9.3

ND - Nondetect

cwm/table.431

TABLE 4-32
PHASE I SEDIMENT RESULTS
INORGANICS

	Ammonia as N (mg/l)	Calcium (mg/l)	COD (mg/l)	Chloride (mg/l)	Cyanide, Total (mg/l)	Magnesium (mg/l)	Nitrate + Nitrite (mg/l)	Phenolics, Total (mg/l)	Potassium (mg/l)	Sodium (mg/l)	Sulfate as SO ₄ (mg/l)
S-1	189.00	75200	75000	135.0	< 1.09	32000	4.00	1.10	2000	150	187.00
S-2	175.00	63400	100000	83.0	< 0.97	28900	1.70	1.30	1700	ND	< 108.00
S-3	133.00	63600	92000	82.0	< 1.01	28300	1.00	2.10	1300	ND	< 102.00
S-4	69.00	47400	58000	34.0	< 0.68	22500	< 0.78	0.46	940	78	< 78.00
S-5	64.00	27900	35500	24.0	< 0.62	13900	2.30	0.79	640	ND	< 67.00
S-7	149	84200	52700	27.0	< 0.66	43300	5.7	< 0.37	870	ND	< 73
S-8	182.00	76300	88000	131.0	< 0.99	36200	2.60	< 1.30	1300	110	204.00
S-9	137.00	62500	93000	58.7	< 1.05	29000	3.60	< 2.20	2100	230	< 112.00
S-11	46.1	59900	62700	73.2	< 0.81	28100	4.4	< 1.5	700	160	216
S-12	164	53000	107000	211.0	< 1.33	18200	7.3	< 2.6	2200	420	634
S-13	192.00	64500	110000	188.0	< 1.26	22700	4.20	< 2.40	2200	400	485.00
S-14	229.00	61300	110000	265.0	< 1.45	20000	10.40	< 2.90	2400	430	397.00
S-15	174.00	110	152	1.2	-	ND	5.70	< 2.00	ND	ND	510.00
S-16	21.10	29500	50000	27.2	< 0.70	15200	3.60	< 1.50	630	100	< 70.00
S-17	119.00	66400	91800	78.0	< 0.90	31500	6.10	< 1.20	1700	120	< 100.00
S-18	61.00	42700	88500	110.1	< 1.08	19600	2.90	< 1.90	1100	95	117.0
S-19	52.80	56100	48200	52.6	< 0.70	28800	1.50	< 0.42	640	180	< 48.90
S-20	46.7	60500	38500	26.4	< 0.73	32900	2.1	< 0.39	580	220	< 70.3

**TABLE 4-32 (Cont.)
PHASE I SEDIMENT RESULTS
INORGANICS**

	Ammonia as N (mg/l)	Calcium (mg/l)	COD (mg/l)	Chloride (mg/l)	Cyanide, Total (mg/l)	Magnesium (mg/l)	Nitrate + Nitrite (mg/l)	Phenolics, Total (mg/l)	Potassium (mg/l)	Sodium (mg/l)	Sulfate as SO ₄ (mg/l)
S-21	31.30	25900	45500	19.3	< 0.68	13700	1.90	< 0.34	700	ND	< 67.90
S-22	8.80	82100	30700	10.3	< 0.63	43700	< 0.61	< 0.72	690	ND	< 61.30
S-23	23.40	42100	36500	37.9	< 0.69	21700	1.60	< 1.30	500	170	< 67.40
S-24	26.7	57100	53000	23.6	< 0.71	29100	4.7	< 0.5	620	370	< 69.3
S-25	172.00	72500	82400	61.6	< 0.79	30600	2.00	< 1.8	770	120	112.00
S-26	132.00	70600	64000	87.0	< 1.08	31100	2.50	< 1.30	1300	130	124.00
S-27	201.00	62400	68000	82.0	< 1.21	24800	3.90	< 1.30	2200	190	153.00
S-28	83.30	59700	73000	31.8	< 0.79	28600	1.80	< 1.00	ND	1400	111.00
S-29	81.00	66600	94500	80.4	< 1.10	25600	< 1.20	< 1.30	1800	150	178.00
S-30	164.00	57000	111000	62.4	< 0.95	18500	6.70	< 1.90	1400	320	< 102.00

ND - Nondetect

cwm/table.432

TABLE 4-33
PHASE I SEDIMENT RESULTS
METALS

	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Copper	Lead	Nickel	Silver	Zinc
S-1	20.0	26.0	0.59	0.77	38.0	66.0	120	39.0	ND	330
S-2	ND	26.0	0.50	0.68	30.0	49.0	91.0	32.0	ND	260
S-3	18.0	25.0	0.45	0.58	28.0	49.0	88.0	30.0	ND	260
S-4	24.0	30.0	0.29	ND	13.0	25.0	50.0	23.0	ND	220
S-5	ND	22.0	0.23	1.40	8.80	ND	29.0	11.0	ND	160
S-6	-	-	-	-	-	-	-	-	-	-
S-7	17.0	32.0	0.29	0.43	14.0	28.0	56.0	18.0	ND	200
S-8	ND	20.0	0.68	2.80	28.0	57.0	110	31.0	2.6	290
S-9	ND	18.0	0.78	1.90	31.0	53.0	120	32.0	2.2	270
S-10	ND	17.0	1.10	2.00	39.0	57.0	160	39.0	ND	310
S-11	ND	15.0	0.42	2.00	15.0	31.0	150	20.0	2.2	190
S-12	ND	17.0	0.88	1.40	ND	46.0	130	33.0	ND	270
S-13	ND	12.0	1.0	2.00	38.0	56.0	150	39.0	ND	310
S-14	ND	3.8	1.0	1.90	37.0	53.0	150	41.0	ND	300
S-15	ND	17.0	0.86	2.70	36.0	65.0	170	40.0	ND	310
S-16	ND	27.0	0.28	0.88	9.20	25.0	33.0	13.0	ND	130

**TABLE 4-33 (Cont.)
PHASE I SEDIMENT RESULTS
METALS**

	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Copper	Lead	Nickel	Silver	Zinc
S-17	22.0	20.0	0.50	0.45	29.0	53.0	94.0	36.0	ND	290
S-18	17.0	14.0	0.35	0.310	20.0	34.0	63.0	22.0	ND	190
S-19	ND	23.0	0.45	3.60	14.0	26.0	46.0	18.0	ND	160
S-20	ND	28.0	0.46	4.00	12.0	23.0	42.0	16.0	1.6	250
S-21	11.0	24.0	0.21	ND	9.10	22.0	29.0	14.0	ND	170
S-22	15.0	35.0	0.21	ND	6.90	21.0	22.0	17.0	ND	55.0
S-23	ND	28.0	0.44	4.00	13.0	31.0	50.0	19.0	ND	240
S-24	ND	87.0	0.51	4.40	16.0	33.0	66.0	21.0	ND	250
S-25	ND	18.0	0.57	2.50	25.0	37.0	77.0	25.0	2.3	240
S-26	ND	21.0	0.64	2.50	30.0	49.0	100	28.0	2.2	280
S-27	ND	18.0	0.99	3.70	51.0	74.0	160	43.0	3.1	410
S-28	15.0	17.0	0.51	0.80	33.0	46.0	110	34.0	ND	373
S-29	26.0	26.7	0.73	0.89	54.0	65.0	150	40.0	ND	380
S-30	ND	16.0	1.20	3.10	72.0	64.0	130	37.0	2.4	420

ND - Nondetect

All concentrations reported as mg/kg

No sample was collected at S-6, insufficient sample volume.

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TABLE 4-34
PHASE II SEDIMENT RESULTS
METALS

PARAMETER (mg/kg)	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10
Antimony	ND	ND	ND	ND	12.0	ND	ND	ND	ND	ND
Arsenic	16.0	14.0	13.0	14.0	8.1	6.5	11.0	7.9	17.0	32.0
Beryllium	1.1	1.2	0.57	1.6	1.6	0.93	0.61	0.47	0.56	1.1
Cadmium	3.6	6.6	3.1	4.5	6.2	4.1	2.5	2.1	2.2	4.9
Chromium	50.0	198	25.0	100	60.0	25.0	30.0	139	13.0	21.0
Copper	35.0	22.0	27.0	24.0	27.0	30.0	27.0	12.0	65.0	60.0
Lead	72.0	48.0	80.0	33.0	37.0	86.0	50.0	41.0	120	400
Mercury	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	16.0	12.0	14.0	18.0	18.0	16.0	15.0	5.0	12.0	16.0
Zinc	97.0	74.0	150	140	140	120	82.0	35.0	120	499

ND - Nondetect
All concentrations in (mg/kg)

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TABLE 4-35
PHASE I SEDIMENT RESULTS
ORGANICS

	Units	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10
Acenaphthene	mg/kg	ND	ND	ND	ND	ND	-	ND	ND	ND	ND
Anthracene	mg/kg	ND	ND	ND	ND	ND	-	0.349	ND	ND	ND
Benzo(a)anthracene	mg/kg	ND	ND	ND	ND	ND	-	ND	ND	ND	ND
Benzo(a)pyrene	mg/kg	0.526	0.589	ND	ND	ND	-	0.539	0.622	ND	ND
Benzo(k)fluoranthene	mg/kg	ND	ND	ND	ND	ND	-	ND	ND	ND	ND
Benzo(b)fluoranthene	mg/kg	ND	ND	ND	ND	ND	-	ND	ND	ND	ND
Crysene	mg/kg	0.908	0.843	0.820	ND	0.424	-	0.678	0.557	ND	ND
Fluoranthene	mg/kg	1.280	1.340	1.220	0.355	0.847	-	1.490	0.973	ND	ND
Fluorene	mg/kg	ND	ND	ND	ND	ND	-	ND	ND	ND	ND
Phenanthrene	mg/kg	ND	ND	ND	ND	ND	-	1.200	ND	ND	ND
Napthalene	mg/kg	ND	ND	ND	ND	ND	-	ND	ND	ND	ND
Pyrene	mg/kg	1.280	1.230	1.070	0.330	0.835	-	1.350	0.844	ND	ND
Phenol	mg/kg	0.881	1.160	1.070	ND	0.840	-	0.792	ND	ND	ND
Heptachlor	mg/kg	ND	ND	0.034	ND	ND	-	0.018	ND	ND	ND
Bis(2Ethylhexyl) Phthate	mg/kg	ND	ND	ND	ND	ND	-	ND	ND	ND	ND
1,2 Trans-Dichlorethylene	mg/kg	ND	ND	ND	0.003	0.002	-	0.012	0.003	ND	ND
Tetrachloroethylene	mg/kg	ND	ND	ND	ND	ND	-	ND	ND	ND	ND
Trichloroethylene	mg/kg	ND	ND	ND	0.002	ND	-	ND	ND	ND	ND
Methylene Chloride	mg/kg	0.011	0.009	0.432	0.035	0.019	-	0.214	0.013	0.011	0.014

ND - Nondetect

No sample was collected at S-6, insufficient sample volume.

**TABLE 4-35 (Cont.)
PHASE I SEDIMENT RESULTS
ORGANICS**

	Units	S-11	S-12	S-13	S-14	S-15	S-16	S-17	S-18	S-19	S-20
Acenaphthene	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Anthracene	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)anthracene	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	mg/kg	ND	ND	ND	ND	ND	ND	ND	0.594	ND	ND
Benzo(k)fluoranthene	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(b)fluoranthene	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Crysene	mg/kg	ND	ND	ND	ND	ND	ND	ND	0.934	0.502	ND
Fluoranthene	mg/kg	9.410	ND	ND	1.460	ND	ND	0.859	1.460	0.799	0.785
Fluorene	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Napthalene	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene	mg/kg	8.220	ND	ND	1.360	4.660	ND	0.750	1.410	0.760	0.681
Phenol	mg/kg	ND	ND	ND	ND	ND	ND	ND	1.060	0.705	ND
Heptachlor	mg/kg	ND	ND	ND	ND	ND	ND	ND	0.043	ND	ND
Bis(2Ethylhexyl) Phthate	mg/kg	ND	ND	ND	ND	ND	ND	8.160	ND	ND	ND
1,2 Trans-Dichlorethylene	mg/kg	ND	ND	0.002	0.003	0.002	ND	0.002	ND	ND	ND
Tetrachloroethylene	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethylene	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	mg/kg	0.012	0.016	0.017	0.015	0.012	0.493	0.022	0.011	0.032	0.037

ND - Nondetect

**TABLE 4-35 (Cont.)
PHASE I SEDIMENT RESULTS
ORGANICS**

	Units	S-21	S-22	S-23	S-24	S-25	S-26	S-27	S-28	S-29	S-30
Acenaphthene	mg/kg	ND	ND	ND	0.316	ND	ND	ND	ND	ND	ND
Anthracene	mg/kg	0.440	ND	ND	0.872	ND	ND	ND	ND	ND	ND
Benzo(a)anthracene	mg/kg	ND	ND	ND	1.230	ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	mg/kg	0.608	ND	ND	0.806	0.833	0.758	ND	0.658	1.100	ND
Benzo(k)fluoranthene	mg/kg	ND	ND	ND	0.611	0.586	0.586	ND	ND	0.987	ND
Benzo(b)fluoranthene	mg/kg	ND	ND	ND	ND	0.879	ND	ND	ND	ND	ND
Crysene	mg/kg	0.627	ND	ND	1.370	0.846	0.875	ND	0.964	1.850	ND
Fluoranthene	mg/kg	1.570	ND	0.621	3.720	1.230	1.590	ND	1.660	2.430	ND
Fluorene	mg/kg	ND	ND	ND	0.742	ND	ND	ND	ND	ND	ND
Phenanthrene	mg/kg	1.410	ND	ND	3.120	ND	ND	ND	ND	1.330	ND
Napthalene	mg/kg	ND	ND	ND	2.010	ND	ND	ND	ND	ND	ND
Pyrene	mg/kg	1.290	ND	0.556	3.450	1.110	1.430	ND	1.450	2.220	ND
Phenol	mg/kg	0.923	0.560	0.820	ND	ND	ND	ND	ND	1.160	ND
Heptachlor	mg/kg	0.015	ND	ND	ND	ND	ND	ND	ND	0.072	ND
Bis(2Ethylhexyl) Phthate	mg/kg	ND	ND	4.530	ND	ND	ND	ND	ND	ND	ND
1,2 Trans-Dichlorethylene	mg/kg	0.003	0.002	ND	ND	ND	ND	0.002	ND	ND	ND
Tetrachloroethylene	mg/kg	ND	0.013	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethylene	mg/kg	ND	0.006	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	mg/kg	0.021	0.033	0.031	0.051	0.453	0.015	0.013	0.057	0.019	0.009

ND - Nondetect

TABLE 4-36
PHASE II SEDIMENT RESULTS
ORGANICS

PARAMETER (mg/kg)	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10
Benzo(a)pyrene	4.74	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(b)fluoranthene	9.29	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(k)fluoranthene	3.60	ND	ND	ND	ND	ND	ND	ND	ND	ND
Crysene	7.16	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	10.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene	12.4	ND	ND	ND	ND	3.30	ND	ND	ND	5.97
Fluoranthene	16.1	ND	2.86	ND	ND	3.39	ND	ND	ND	8.07
Benzene	ND	ND	ND	0.013	0.008	ND	ND	ND	ND	ND
Di-n-butyl Phthalate	ND	ND	ND	ND	ND	17.9	ND	ND	ND	ND

ND - Nondetect
All concentrations in (mg/kg).

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Surface Water Sample Analytical Results

Results of the surface water sample analyses for the samples collected during Phase I indicate relatively low cation and anion concentrations. (Historical inorganic data was not available for comparison.) A comparison of relative ion concentrations cannot be made however, because background surface water data for Lake Calumet and surrounding hydrologic systems are not available. Cation concentrations were consistently low in sample SW-4 and consistently high in sample SW-2 compared to values measured in the other samples collected during Phase I. Magnesium concentrations ranged from 12.2 mg/L in sample SW-4 to 27.6 mg/L in sample SW-2. Similarly, potassium concentrations ranged from 2.7 mg/L to 14.0 mg/L, sodium concentrations ranged from 24.0 mg/L to 71.8 mg/L, and ammonia ranged from 0.29 mg/L to 2.8 mg/L in samples SW-4 and SW-1, respectively.

Anion concentrations showed similar trends for chloride and sulfate, but nitrate + nitrite was dissimilar. Chloride concentrations ranged from 40.6 mg/L to 101 mg/L, and sulfate concentrations ranged from 34.6 mg/L to 114 mg/L, in samples SW-4 and SW-2, respectively. Nitrate + nitrite ranged from 0.16 mg/L in SW-2 to 0.45 mg/L in sample SW-1.

Low values for "typical" surface waters were obtained for alkalinity, total dissolved solids, and total suspended solids. Alkalinity was measured at a concentration of 120 mg/L in samples SW 1, SW-3, SW-4, and SW-5 and at a concentration of 140 mg/L in sample SW-2. TDS concentrations ranged from 200 mg/L in sample SW-4 to 430 mg/L in sample SW-2. TSS concentrations ranged from 38 mg/L in sample SW-4 to 124 mg/L in sample SW-1.

The organic parameters BOD, COD, and TOC were measured during the Phase I Investigation. BOD concentrations were relatively consistent in each of the 5 samples, ranging from 2.0 to 4.0 mg/L. COD and TOC concentrations were more erratic. COD concentrations ranged from

non-detectable levels in samples SW-4 and SW-5 to 34 mg/L in sample SW-2. TOC concentrations ranged from 3.5 mg/L in samples SW-3 and SW-5 to 13.1 mg/L in sample SW-1.

These previously discussed parameters were exclusive to the Phase I sampling events. Parameters evaluated in both Phase I and Phase II are described below.

The halogenated organic compound methylene chloride was the only organic contaminant detected in surface water during either the Phase I or Phase II sampling events. Methylene chloride was detected in samples SW-2, SW-3, and SW-5, and in the field blank at concentrations ranging from 2.82 $\mu\text{g/L}$ to 8.69 $\mu\text{g/L}$. The presence of methylene chloride in the field blank at a concentration comparable to the other samples indicates that this constituent is most likely a lab artifact.

The values obtained for the indicator parameters pH and specific conductance are relatively consistent between sample locations for both the Phase I and Phase II sampling efforts. The pH values ranged from 7.60 in sample SW-12 measured during Phase II to 8.43 in sample SW-3 measured during Phase I. The pH values measured in the laboratory were generally lower than field measurements. The pH values indicate that the water in Lake Calumet is slightly basic.

Specific conductance values ranged from 450 $\mu\text{m/cm}$ to 813 $\mu\text{m/cm}$. The lowest reading was measured in sample SW-5 during the Phase I sampling event while the highest reading was measured in sample SW-1 during the Phase II sampling event. The relatively low specific conductance values are consistent with the low concentrations of inorganic constituents measured in the samples.

Mercury was detected in sample SW-5 at a concentration of 0.20 $\mu\text{g/L}$ during the Phase II sampling event. No other heavy metals were detected during the Phase I or Phase II sampling

events. With the exception of methylene chloride discussed above, no volatile or semi-volatile organic constituents were detected in the surface water samples collected for this investigation.

Table 4-37 lists all constituents analyzed and the concentrations of detected constituents, and the detection limits of all constituents, at nearby sampling locations. These samples were collected at similar locations during Phase I (nine locations) and Phase II (ten locations) of the investigation. No significant change between phases has occurred.

Sediment Sample Analytical Results

The concentrations of inorganic ions in sediment samples collected in Lake Calumet during Phase I are considerably higher than concentrations in surface water samples. Concentrations of calcium range from 57,000 to 84,200 mg/kg. Magnesium concentrations range from 20,000 to 43,700 mg/L. Potassium and sodium concentrations ranged from 580 to 2900 mg/kg and 78 to 2,100 mg/kg respectively.

Chloride concentrations in the sediment samples ranged from 10.3 to 265 mg/kg. Sulfate concentrations ranged from 112 to 580 mg/kg. Ammonia concentrations ranged from 8.8 to 229 mg/kg. Nitrate + nitrite nitrogen concentrations ranged from non detectable levels to 10.7 mg/kg.

Eleven of the 16 priority pollutant metals analyzed were detected in sediment samples collected during the Phase I and Phase II sampling events. Antimony was detected in 10 of the 30 sediment samples collected during the Phase I sampling event. Concentrations ranged from 10 to 30 mg/kg. Antimony was detected in only 1 of 10 sediment samples collected during the Phase II sampling event. Concentrations of antimony detected in this investigation are above

the average concentrations detected in previous studies of Lake Calumet sediments and surrounding water systems (USACE, 1985).

Arsenic was detected in each of the sediment samples collected during both the Phase I and Phase II sampling events. Arsenic concentrations ranged from 3.2 mg/kg at sample location S-14 to 87 mg/kg at S-24, both collected during Phase I. S-24 is located in Slip No. 6, halfway between the two piers. Sediment samples S-6 and S-7, located between the pier and sample S-24, detected arsenic at concentration of 6.5 and 11.0 mg/kg respectively. Sediment samples S-6 and S-7 were collected during Phase II of the investigation.

Beryllium was detected in each of the sediment samples collected during the Phase I and Phase II sampling events. Beryllium concentrations ranged from 0.21 to 1.6 mg/kg. Beryllium concentrations in sediments do not appear to be excessively high. No background data is available for comparison.

Cadmium was detected in 87% of the sediment samples collected during the Phase I sampling event and in each of the sediment samples collected during the Phase II sampling event. Cadmium concentrations ranged from nondetect (ND) to 6.6 mg/kg. The highest cadmium concentrations were measured in samples collected near the pier during Phase II. However, concentrations of cadmium are consistent with average cadmium concentrations detected in sediment samples collected from Lake Calumet and surrounding water systems during previous studies.

Chromium and copper were detected in each of the sediment samples collected during the Phase I and Phase II sampling events. Chromium concentrations ranged from 6.9 to 198 mg/kg. The highest chromium concentration was detected in sample S-2 (Phase II) located north of the biobeds. Generally, higher chromium concentrations were measured in samples collected near the pier (Phase II) and interior of the slips (Phase I). Chromium concentrations in Lake Calumet

are elevated relative to average concentrations in surrounding hydrologic systems and extremely elevated relative to the IEPA classification of sediments which is based on average background values. Copper concentrations ranged from non-detect to 74 mg/L. The slightly elevated copper concentrations are comparable to concentrations in samples collected in Lake Calumet and surrounding hydrologic systems during previous studies. No trends between Phase I and Phase II data for copper can be seen.

Lead was detected in each of the sediment samples collected during the Phase I and Phase II sampling events. Lead concentrations ranged from 33 to 400 mg/kg. The highest concentration was detected in sample S-10 (Phase II) located directly north of the vault. In addition, Phase I samples collected in the slip north of the pier yielded values in excess of 100 mg/L. Lead concentrations in Lake Calumet are elevated relative to average concentrations in surrounding hydrologic systems and extremely elevated relative to the IEPA classification of sediments which is based on average background values.

Mercury was detected in only 1 of the 10 sediment samples collected during the Phase II sampling event. Mercury was detected at a concentration of 0.15 mg/kg in sample S-10. Mercury was not detected in sediment samples collected during the Phase I sampling event.

Nickel and zinc were detected in each of the sediment samples collected during the Phase I and Phase II sampling events. Nickel and zinc concentrations ranged from 5 to 43 mg/kg in Phase I samples and 35 to 499 mg/kg in the Phase II samples. The highest nickel concentration was detected in sample S-27 (Phase I) located within the slip south of the pier. No trends in nickel data can be seen. The highest zinc concentration was detected in sample S-10 (Phase II) located directly north of the vault. However, the range of zinc concentrations between all sampling points are comparable. Nickel concentrations are comparable to concentrations detected in sediment samples collected in surrounding hydrologic systems during previous studies. Zinc

concentrations in Lake Calumet are elevated relative to average concentrations in surrounding hydrologic systems.

Silver was detected in 8 of the 30 samples collected during the Phase I sampling event but were not detected in any Phase II samples. Silver concentrations ranged from 1.6 to 3.1 mg/kg. Silver concentrations are slightly elevated relative to concentrations detected in sediment samples collected in surrounding hydrologic systems during previous studies.

Concentrations of organic compounds collected in Phase I sediment samples (i.e. COD) were also significantly higher than surface water sample measurements. Chemical oxygen demand concentrations range from 38,500 to 116,000 mg/kg. The lowest COD value was measured in sample S-20 located west of the pier. The highest concentration was measured in sample S-10 located north of the wastewater basin (SWMU #6). These values are consistent with concentrations of other samples collected in Lake Calumet and surrounding hydrologic systems during previous investigations (Ross, 1988).

Ten polynuclear aromatic hydrocarbon (PAH) compounds were detected in sediment samples collected during the Phase I sampling. Seven PAH compounds were detected during the Phase II sampling. PAH compounds detected in sediments during the investigation include: acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, fluoranthene, naphthalene, phenanthrene, phenol, and pyrene. Concentrations of PAH compounds ranged from 4.33 to 20.67 mg/kg. PAH compounds appeared to be more numerous in Phase I than Phase II samples. However, the highest concentrations were measured in sample S-1 (Phase II) collected immediately north of the east biobed area. The Phase I samples were consistent at lower concentrations in samples collected from the slips and the lake west of the pier.

Five halogenated hydrocarbon compounds and one aromatic hydrocarbon compound were detected in sediment samples analyzed during the investigation. The halogenated compounds 1,2-trans-dichloroethylene, methylene chloride, tetrachloroethylene, and trichloroethylene were detected in sediment samples during the Phase I sampling event. With the exception of methylene chloride, which was measured in each sample collected during Phase I, the other compounds were detected at sporadic locations at concentrations ranging from .002 mg/kg to .012 mg/kg. During Phase II, the aromatic hydrocarbon benzene was detected in samples S-4 and S-5 at concentrations of 0.013 and .00761 mg/kg respectively.

Phenols were detected at 10 sample locations during Phase I at concentrations ranging from 0.56 mg/kg to 1.16 mg/kg. No spatial pattern of detects can be observed. No phenols were detected in Phase II samples.

Two phthalate compounds were detected in sediment samples collected during the investigation. Bis(2-ethylhexyl)phthalate was detected in samples during Phase I at concentrations ranging from 4.53 to 8.16 mg/kg. Di-n-butyl-phthalate was detected in a sediment sample during Phase II at a concentration of 17.9 mg/kg.

Concentrations of organic and inorganic constituents present in sediment samples collected during both phases were evaluated. Table 4-38 presents the results of sediment samples within the slips and the Phase II sediment samples collected near the pier. Each sediment sample collected in the Phase II sampling was compared to the closest sediment sample location from Phase I. These sample points are typically 100 to 200 feet apart. A limited number of semivolatile organic compounds, primarily PAH compounds, were detected in both Phase I and Phase II sediment samples. Significant concentrations of metals were detected in all sediment samples. Elevated levels of metals include lead, chromium, and arsenic.

Sample S-30 collected during Phase I presents the only significant change between Phase I and Phase II. Volatile organic compounds (VOCs), primarily chlorinated ethanes, and ethenes were detected in this sample. These constituents were not detected in adjacent Phase II samples S-4 and S-5. No identifiable trend can be distinguished between Phase I and Phase II sediment sample results. Some constituent concentrations exhibited an increase while others decreased.

It is difficult to determine a contaminant distribution pattern for the Lake Sediments. Based on the higher detection limits of sediment samples collected in the slips, contamination in the slips is greater than contamination in the lake. However, the actual number of detected compounds is greater in sediment samples collected from the lake.

Data Evaluation

Analytical data obtained for sediment samples collected during this investigation indicate that the sediments in Lake Calumet are contaminated primarily by heavy metals and polynuclear aromatic compounds. These data are consistent with previous studies performed on Lake Calumet and other surrounding hydrologic systems.

Previous studies (Ross, et. al., 1988, 1989) indicate areas of heavy metal and PAH concentrations located throughout the lake system. Heavy metal concentrations appear to be highest in areas of low surface water flow or areas of sediment deposition. The highest concentration of metals and PAH compounds appear to be associated with runoff into the lake from Pullman Creek. Pullman Creek is located west of the CWMCS facility on the opposite side of Lake Calumet.

The shallow depth of the lake, the high degree of mixing at the water sediment interface, the flocculent nature of the sediments, and the high concentrations of metals in the sediments suggest

that metals could be released from the sediments to the overlying water column. The resuspension and deposition of bottom materials is likely a significant contaminant transport mechanism in the lake. However, the analytical results for the surface water samples do not indicate that metals are being released to the water column.

The primary attenuation processes controlling metal ion concentrations in surface water are absorption-desorption, solution-precipitation, and biological uptake. Metal ions are relatively immobile in normal surface waters due to their limited solubility and their affinity for adsorption to sediment particles. Metal ions become more mobile in conditions of extreme pH which exerts an influence on the solubility and adsorption of these contaminants. The pH of the surface water measured during this investigation indicates neutral to slightly basic conditions in Lake Calumet.

This study did not detect any discernable immiscible or dissolved contaminant plumes originating from the CWMCS facility. The inorganic and metals data for near-shore and far-shore sample locations do not show conclusive evidence that such plumes or contaminant migration exists. Although one sample from Phase II north of the east biobed yielded fairly high PAH values, the lack of PAH detects in other Phase II sediment samples indicates that the PAH contamination in the distant lake samples (Phase I) likely originates from another source. The remaining organic contaminants measured in both Phase I and Phase II samples are widely sporadic and not significant. The contaminants in the sediments of Lake Calumet are an accumulation of over 100 years of industrial activity in the area. This history along with the known complicated flow and depositional patterns in the lake render it virtually impossible to attribute any facility impacts on the Lake Calumet hydrologic system.

5.0 POTENTIAL RECEPTORS

Identification of potential receptors is essential to perform a risk assessment, used for selection of cleanup goals and the remedial alternatives. The human health and ecological risk assessment studies are presented as separate documents.

5.1 Regional Demography

Given the observed distribution of contaminants throughout the site and that contaminated areas are not accessible by the public, exposures by members of the public are not likely. Furthermore, no one currently lives on-site and the nearest residential dwelling is located about 0.8 miles from the site. The site is located in an area that is zoned heavy industrial and used almost exclusively for waste management operations. Given the industrialized nature of the surroundings, it is highly unlikely that members of the public would routinely frequent areas on or near the site. In addition, future development of the site is not compatible with residential development in an area that includes an incinerator and large municipal landfills. Thus, the combination of deed restrictions associated with post-closure activities, EPA guidance, and the industrialized nature of the surrounding area makes future residential development of this site highly improbable. Hence, future use of this site is expected to remain commercial/industrial.

Although most of the site is fenced, the western portion of the pier is unfenced and extends into Lake Calumet, making it accessible to trespassers. On the other hand, the pier offers little attraction to trespassers. The open, unfenced area is covered with tall, weedy vegetation most of the year. The surrounding area is heavily industrialized and often malodorous. The only means of accessing this portion of the site is by boat or by wading across the water. Although the water level around the site can drop during dry months, individuals would usually have to wade through about three to five feet of water. The land edge is relatively steep and rocky versus being flat or beach-like. Furthermore, trespassing was not considered likely during the

harsh winter months (i.e., December through March) when the lake freezes. Access from the active (land end) of the site is not likely, because the area is fenced and secure. Thus, potential exposures by individuals who might access the open end of the pier were considered improbable.

5.2 Current and Future Use of Groundwater

Groundwater within the uppermost water-bearing unit is in hydraulic connection with Lake Calumet. Earlier groundwater assessments (11) indicated that the groundwater in the uppermost water-bearing unit is not likely to be contaminated from the interim status surface impoundments. These same studies showed that the underground pipeline failure of October 1984, which released scrubber water into the uppermost water-bearing unit, temporarily increased contaminant levels in the surrounding groundwater. Subsequent groundwater flushing, however, reduced these contaminant levels to their previous levels. Contaminant levels measured in the uppermost water-bearing unit monitoring wells (the RFI wells) indicate contamination from the historical facility operations.

Future releases to groundwater were evaluated in the Exposure Information Report for both the interim status surface impoundments and the lower Silurian bedrock aquifer (EIR) (12). Breakthrough time of the interim status surface impoundment clay liner for a chemical constituent (assuming no attenuation) was estimated to be 6.9 years. Because of the closure and the previous history of this site, future contamination of groundwater via this route is considered insignificant. The breakthrough time for similar compounds to the lower aquifer was estimated to be 226 years. This computation assumes a vertical permeability of 2×10^{-7} cm/sec, an aquitard (silt and clay till) thickness of 60 feet, and an effective porosity of 20 percent. However, because of the influence of Lake Calumet and its connection to the fill materials, the majority of hazardous constituents in groundwater are expected to be released to the lake rather than to the lower aquifer. The work performed for the RFI substantiates the assumptions made in the EIR report.

There are very few production/drinking water wells within a one-mile radius of the site because: (1) most residents and commercial establishments use Chicago City (municipal) water, and (2) much of the surrounding land, although zoned industrial, is undeveloped. Furthermore, since each of the existing wells has been screened in the bedrock aquifer underlying the clay tills, contamination of these wells is not likely. In addition, the Illinois State Water Survey indicated that within the township in which the facility is located, no groundwater is drawn for public use, although 54,000 gallons a day is pumped for industrial (non-consumption) purposes (24). As a result, the impact on human health from groundwater use in the area is expected to be minimal. Furthermore, current and future workers are not expected to consume the local groundwater, since drinking water is currently available from a municipal source.

5.3 Current and Future Use of Surface Water

All surface water releases are eventually discharged into Lake Calumet where potentially hazardous contaminants would be inevitably diluted. In addition, Lake Calumet is classified as a secondary use water system; hence, it is not used as a drinking supply. Lake Calumet is not utilized for swimming. Consequently, dermal absorption and incidental ingestion of contaminants via this pathway are not viable. Individuals have been observed to fish near the CWMCS pier. While the occasional recreational fisherman is expected to represent the population most likely to be exposed to site-related contaminants in surface water and sediment, subsequent human exposures from the ingestion of fish contaminated due to release from the CWMCS site were not considered quantified for the following reasons. Any fish taken from Lake Calumet will doubtless be contaminated with chemicals from several sources, not just chemicals originating from the CWMCS site. In addition to the effects of over 100 years of contaminations, Lake Calumet is currently impacted by a variety of non-point sources, including highway runoff, surface runoff from industrial properties, and seepage of contaminated groundwater from nearby landfills, dumps, waste lagoons, and underground storage tanks

(IDENR, 1988). Hence, exposures from ingestion of fish contaminated with chemicals released from the CWMCS site was deemed too uncertain to quantify.

5.4 Exposures by On-Site Workers

Inhalation can be a major pathway of exposure for contaminants that readily volatilize from soil or water surfaces via inhalation of wind-generated dust. Similarly, individuals working on-site could be exposed to contaminants from the incidental ingestion of and dermal contact with contaminated soil/dust. Since most of the site is dry and surface contamination exists, current on-site workers are another potential receptor group.

5.5 Potential Ecological Receptors

Potential ecologic receptors associated with the CWMCS Facility include organisms inhabiting and frequenting the Lake Calumet area adjacent to the incinerator. These potential receptors include fish and invertebrates inhabiting Lake Calumet and various bird species that frequent and/or inhabit the shorelines of Lake Calumet.

Biosurvey data for fish from Lake Calumet and adjacent areas was collected in the early 1980's. Results indicate that a total of 27 fish species from 10 families inhabit the lake (13). The more frequently occurring sport fish species include bluegill, largemouth bass, and yellow perch. Common carp, gold fish, and various cyprinids (minnows) also occur within Lake Calumet and its associated wetlands. No threatened and endangered (T&E) aquatic organisms are known to occur, although Lake Calumet is a designated Illinois Natural Area.

Plant species listed as endangered by the State of Illinois that could occur in the area include Small White Lady's Slipper (*Cypripedium canadum*), Little Green Sedge (*Carex viridula*), Fewflower Spike Rush (*Eleocharis pauciflora*), and Richardson Rush (*Juncus alpinus*) (personal

communication from Deanna Glosser, Illinois Department of Conservation, October, 1993). None of these species were observed on-site during field reconnaissance conducted in the Fall of 1993. The site has been recently disturbed or has soil conditions that are not conducive to vegetation growth. Vegetation within the project area consists primarily of invader and weedy species that form a mosaic in conjunction with varying site conditions. A variety of habitats is provided by different soil moisture regimes and disturbance histories.

Bird species occurring in the Lake Calumet area include 11 species listed as endangered by the State of Illinois (personal communication from Deanna Glosser, Illinois Department of Conservation, October, 1993): the Pied Billed Grebe (*Podilymbus podiceps*), the Black-Crowned Night Heron (*Nycticorax nycticorax*), the Common Moorhen (*Gallinula chloropus*), the Upland Sandpiper (*Bartramia longicauda*), Wilson's Phalarope (*Phalaropus tricolor*), the Black Tern (*Chlidonas niger*), the Yellow-Headed Blackbird (*Xanthocephalus xanthocephalus*), the Great Egret (*Casmerodius albus*), the Least Bittern (*Ixobrychus exilis*), the American Bittern (*Botaurus lentiginosus*), the Yellow Rail (*Coturnicops noveboracensis*), the Red-Shouldered Hawk (*Buteo lineatus*), and the Northern Harrier (formerly known as the Marsh Hawk) (*Circus cyaneus*). Cormorants were observed in the general area of the site during the fall of 1993. Other non-endangered bird species potentially inhabiting or frequenting Lake Calumet include water fowl, such as ducks and geese, and shorebirds, such as killdeer and gulls. Other avian receptors would include various passerine (or perching birds) typically occurring in developed or urban/suburban environments. These species may include black birds, starlings, jays, swallows, larks, and sparrows. In addition, the site has been used by gulls, presumably herring gulls, for nesting and fledgling their young. The isolation afforded by the fence and surrounding water provides a sanctuary for the breeding gulls. Concern has been raised about the number of dead gulls observed on the western half of the pier. The observed mortality is not expected to be attributable to site-related contaminated for the following reasons: (1) surface water around the pier that the gulls might ingest is relatively uncontaminated, (2) gulls do not consume large quantities of soils while feeding; (3) contaminants are not likely to be absorbed through the skin. Possible explanations of the gull deaths include: (1) lack of sufficient food to support the

existing population since the closure of the Paxton II Landfill across the street from the CWMCS site, and (2) Robert and Ralph (1975) found that disturbance (e.g., humans routinely walking through the area) during pre-fledgling can cause massive mortality in young. As the young flee an intruder they may leave their own territory and be subjected to aggression by other adults and young.

Given that part of the CWMCS site is a man-made pier constructed of fill (i.e., native soils are not present) and that the site is located in a highly industrialized area, habitat for a majority of the indigenous small mammal species is limited or non-existent. Large mammals are not likely to frequent the site, however, as the eastern portion of the site is enclosed by a tall chain-link fence. The fence essentially isolates approximately one-half of the pier and encloses the remainder of the pier from any large mammal encroachment.

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APPENDICES

**CWM CHEMICAL SERVICES, INC.
CHICAGO INCINERATOR FACILITY
FINAL RCRA FACILITY INVESTIGATION REPORT
PART TWO
EVALUATION OF
CORRECTIVE MEASURES TECHNOLOGIES**

FEBRUARY 1995

Dames & Moore No. 13963-055

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1.0 INTRODUCTION

1.1 Purpose

The purpose of Part Two of the Final RFI Report is to identify potential corrective measures that may be used for the containment, treatment, remediation, and/or disposal of contamination. This is Task IV of the RCRA Corrective Action Plan. The evaluation of corrective measures technologies is a preliminary method intended to identify data needs for a Corrective Measures Study. Data needs may be identified in Laboratory, Bench Scale Studies, or other types of evaluations (Task VI of the RCRA Corrective Action Plan). The Corrective Measures Study consists of Tasks VIII through XI of the RCRA Corrective Action Plan.

Potential corrective measures technologies were screened, eliminating those corrective measures which have severe practical or technical limitations for site specific conditions. Potential corrective measures were reviewed and the feasibility of each option to protect human health and the environment, as well as the relative cost and acceptability of the method, were evaluated. Primary considerations used in assessing potential corrective measures include the following:

- Technical Feasibility;
- Implementation Feasibility;
- Environmental Feasibility; and
- Economic Feasibility.

The technical feasibility of a corrective measure is evaluated with respect to site conditions. This includes the hydrogeologic conditions, characteristics of soil units, extent of contamination, and contaminant migration pathways. The implementation feasibility is evaluated on the basis of design considerations, equipment requirements, treatment and disposal requirements,

monitoring requirements, and permitting requirements. Environmental feasibility is the evaluation of potential adverse impacts associated with the corrective measure. This includes an assessment of the need and feasibility of remediating all environmental media and assessing exposure pathways. This assessment includes evaluation of the potential impacts in the absence of remediation. The economic feasibility of implementing various corrective measures was also assessed. Economic feasibility is based on a comparison of the relative costs associated with implementing each of the options. This includes an evaluation of the cost/cleanup effectiveness of each option. Economic considerations include capital expenditures, design and installation costs, and operation and maintenance costs.

1.2 Background

Two phases of an investigation have been completed at the CWMCS facility. Work performed during each phase of investigation was done in accordance with approved Work Plans. Details of the investigation are presented in Part One (Facility Investigation) of this report.

During the investigation, samples of groundwater in the uppermost water bearing unit, soil samples of the fill material, soil samples of the underlying clayey glacial deposits, and Lake Calumet surface water and sediment samples were collected. Results of groundwater and soil samples collected from the fill indicate that groundwater and soil contamination are present in this fill. Soil samples collected from beneath the fill indicate that a clay layer is serving as a barrier to downward contaminant migration. The fill is in hydraulic connection with Lake Calumet surface water. Migration of contaminants in the fill is towards the lake. Contamination of Lake Calumet resulting from the CWMCS facility could not be confirmed from investigation data because of other significant contaminant sources in the vicinity. Historical industrial activities in the Lake Calumet region have resulted in widespread contamination.

2.0 EVALUATION OF POTENTIAL CORRECTIVE MEASURES

2.1 Screening of Corrective Measures

In the event that a threat to human health or the environment is identified, potential corrective measures must be evaluated. These corrective measures should evaluate options for containment, treatment, remediation, and/or disposal of contamination. Corrective measures that may be used to achieve this objective can be divided into six categories as follows:

- No Action;
- Containment;
- Remediation;
- Treatment;
- Disposal; and
- Resource Management.

Appropriate corrective measures may include one or a combination of these categories. A brief description of potential corrective actions by category is presented below.

No Action

This option assumes that no additional work is required. The no action alternative does not appear to be a feasible option for the CWMCS facility at this time, unless an alternative standard is developed. However, this alternative could be applied to various units or portions of the facility. A no action corrective measure should be re-evaluated following completion of the Risk Assessment.

Containment

Containment is the control of migration of contaminants from the facility. This control prevents the potential for exposure to contamination and prevents additional areas from becoming contaminated. Containment is accomplished by utilizing engineering controls applicable to site conditions to create impermeable barriers. Engineering controls include slurry walls, sheet pilings, grout curtains, or capping. Containment is a feasible option and will be evaluated further in Section 2.2.

Remediation

Remediation is the restoration of the site to original conditions, or to an acceptable level such that little or no risk to human health and the environment results. Restoring the CWM facility to original conditions (a lake bed) is not a feasible option. However, restoration of the site to an acceptable level is feasible and is evaluated in Section 2.2.

Treatment

Treatment is a process that removes, separates, or reduces the toxicity of harmful constituents from the contaminated media (*i.e.*, soil and groundwater). This is accomplished by a variety of physical, chemical, and biological processes. Several treatment options are feasible. These are evaluated with remediation alternatives in Section 2.2.

Disposal

Disposal implies removal of the contaminant source and/or contaminated media, followed by off-site or on-site long term storage of potentially harmful constituents to protect human health and the environment. For contaminated soils, this means removal by excavation or other viable means and placement of the material in a landfill. Deep well injection is a disposal option for contaminated groundwater. Disposal does not appear to be a feasible corrective measure at this time.

Resource Management

Resource management involves various regulatory and administrative decisions intended to limit or prevent exposure of potentially harmful constituents to human health and the environment. This can be accomplished by a combination of corrective measures. Resource management has been evaluated in Section 2.2.

2.2 Potential Corrective Measures

2.2.1 Containment

Installation of an impermeable barrier around the perimeter of the CWMCS facility (or selected SWMUs), in conjunction with a cap to reduce infiltration, is technically feasible. The fill unit is in direct hydraulic connection with Lake Calumet. As a unit, the fill material is a potential contaminant migration pathway. Horizontal migration of contaminants via groundwater is the primary mechanism for potential off-site contamination. Despite the fact that there is a negligible release of contamination to Lake Calumet, containment would reduce future releases of potentially harmful constituents into Lake Calumet.

Containment is a proven and effective technology. The implementation of an impermeable barrier around the perimeter of the facility, such as a slurry wall, is feasible. A low permeability clay layer 15 to 20 feet beneath the fill provides a vertical barrier to contaminant migration. A low permeability cap such as compacted clay, asphalt, or concrete may reduce infiltration substantially. Further remedial measures, such as pumping and treating groundwater may also be part of this system. Although a detailed evaluation of this option is beyond the scope of this screening study, containment appears promising.

Potentially harmful constituents are not destroyed or reduced with containment. However, containment is environmentally feasible since exposure of harmful constituents to human health and the environment are significantly reduced. Containment is also economically feasible. Design and installation costs relative to other corrective measures would be moderate. Operation and maintenance costs would be low.

There are several factors which also must be considered when evaluating this corrective measure. Future land use should be restricted to preclude unnecessary exposure to harmful constituents contained within the property boundaries of the facility. This is consistent with existing land use restrictions imposed by deed restrictions required by RCRA and the responsibilities associated with post-closure activities by RCRA regulated land disposal units. Material used to construct the impermeable barrier must be compatible with the concentrations and types of contamination identified at the facility. Bench scale studies, literature reviews, or information provided by vendors are needed to select a compatible material of which to construct containment barriers.

2.2.2 Remediation

Remediation or site restoration to an acceptable level of risk is technically feasible. Goals for an acceptable level of site restoration should be defined following approval of the Risk Assessment. Corrective measures evaluated for site restoration include the following:

- Groundwater Extraction and Treatment
- Soil Vapor Extraction
- Solidification/Stabilization and/or Encapsulation
- Bioreclamation
- Thermal Treatment by Incineration

Groundwater Extraction and Treatment

Groundwater extraction and treatment is a technically feasible option for remediating groundwater contamination in the uppermost water bearing unit. Implementation of a groundwater extraction system using horizontal subsurface drains would be more feasible than vertical extraction wells. This is based on the shallow depth to groundwater, wide range of permeability, and size of the facility. Groundwater extraction should be concentrated in areas with significant groundwater contamination, such as the biobed areas (SWMU #1). Placing subsurface drains below the elevation of Lake Calumet would create a sink, reversing the direction of groundwater flow.

Groundwater extraction is environmentally feasible since contaminants are removed from the fill, and the potential migration of contaminants will be controlled. However, some constituents will adhere to soil particles and residual contamination would remain. Additionally, groundwater extraction may take 20 to 30 years of operation to complete. Remediation could be completed much sooner if containment barriers were installed reducing infiltration and recharge from Lake Calumet. Design and installation costs would be moderate. Operation and maintenance costs relative to other corrective measures would be moderate to high. These costs are dependent on the duration of pumping required to remediate the facility. The longer the system is in operation, the higher the costs incurred.

The major limitation of a groundwater extraction corrective measure would be the treatment of contaminated water or the permitting requirements for discharging the treated groundwater. A complex treatment system may be required to handle the wide range of both inorganic and organic constituents detected in groundwater samples collected during the investigation. A pilot test may be needed to determine flow rates and feasible treatment systems. Appropriate treatment systems include air stripping, activated carbon treatment, and discharge to the sanitary sewer.

Soil Vapor Extraction

Soil vapor extraction (SVE) uses air as a carrier to remove volatile constituents from the soil. This corrective measure is technically feasible, but has several limitations. An SVE system will not be effective at removing metals or semi-volatile compounds. Permitting may be required prior to discharging off-gases into the atmosphere. Treatment of off-gases may also be required. Because of the high water table conditions in the fill, an SVE system would necessarily be implemented in conjunction with a groundwater extraction and treatment system.

An SVE system would be most effective at treating sources of contamination where a high rate of reduction is needed, such as in the biobeds area, the high solids basin (SWMU#4), the wastewater basin #2 (SWMU#6), and the former Hyon tank farm area. Implementation is feasible for facility conditions. The SVE system would be most effective in areas with high concentrations of volatiles, in conjunction with a groundwater extraction system or air sparging. The groundwater extraction system would lower the water table, and increase the area of SVE influence. SVE is an environmentally feasible method to remove contamination from the soil providing off-gases can be controlled or treated prior to release into the atmosphere.

Solidification/Stabilization and Encapsulation

Solidification/stabilization (this method includes ex-situ bioreclamation) and encapsulation are both soil remediation potential corrective measures. These methods involve the excavation of contaminated soil, followed by mixing with material that alters the physical and/or chemical properties of the contaminated soil, rendering them less leachable and less toxic. Solidification/stabilization and encapsulation are both technically feasible for the CWMCS facility. Both are proven and effective technologies. Solidification has been performed at the facility as part of the pier restoration project in 1982. Implementation would be most effective for areas such as the biobeds area, the high solids basin and wastewater basin #2. Contaminated groundwater encountered in all excavations would have to be collected and treated. The

establishment of a Corrective Action Management Unit (CAMU) would need to be approved so that materials can remain on-site. Pilot tests to determine a compatible material to mix with the soil may be required. This method is environmentally feasible if proper measures are implemented to prevent human exposure or undesirable releases of potentially harmful constituents. Runoff, dust emissions, and vapor emissions would all have to be controlled. The cost to implement this corrective measure would be high since a large volume of material would be handled. Operation, monitoring, and maintenance costs would be low to moderate.

Bioreclamation (In-situ)

This potential corrective measure is a technique for treating zones of contamination by microbial degradation of constituents harmful to human health and the environment. This method is technically feasible and could be used to remediate contaminated groundwater and soil. Although microorganisms are naturally occurring, the process can be enhanced with the addition of hybrid microorganisms, oxygen, or nutrients. The most efficient implementation of a bioreclamation system would be the use of wells to inject nutrients, in conjunction with subsurface drains to collect groundwater downgradient from the injection point. Pilot studies may be required to determine the efficiency and feasible methods of implementation. Bioreclamation would not be effective at removing metals. This method is environmentally feasible in terms of reducing or destroying organic constituents. However, this would be a long term corrective measure, and long term monitoring may be required. Design and installation costs would be low to moderate. Monitoring, operation and maintenance costs would be moderate to high.

Thermal Treatment by Incineration

Thermal treatment could be accomplished by excavating contaminated soils and destroying harmful constituents by incineration. Treated soils may be returned to the excavation. This option is technically feasible for the CWMCS facility because an incinerator is located on the property, making the implementation possible. Runoff, dust emissions, and vapors encountered during excavation would need to be controlled. This method would be most efficient for destroying organic compounds. These areas include the biobeds, the high solids basin and wastewater basin #2. Incineration is less effective for treating metals. Destruction of organic compounds by incineration is also environmentally feasible since off-gases are treated. The cost to implement this corrective measure would be high, especially in areas where existing structures are located. Long term monitoring, operation and maintenance costs would be low.

2.2.3 Resource Management

Resource management is a combination of corrective measures. Land use restrictions on the property will be in place due to the presence of engineered structures designed to provide long term containment for contaminated media, including the area of the former interim status surface impoundments and the vault. Future residential or recreational use of both Lake Calumet and facility is highly unlikely due to former and present land uses. Surface water or groundwater in the uppermost water bearing unit are not currently being used as a water supply, nor are they expected to be used as a water supply in the future.

These corrective measures protect human health by reducing potential exposure to potentially harmful constituents. The mobility, toxicity, or presence of harmful constituents will not be reduced. Resource management should be re-evaluated once the Risk Assessment has been approved. Additional studies or investigation may be required to fully assess these corrective measures.

3.0 SUMMARY AND CONCLUSIONS

Based on the current amount of information available following both phases of investigation, it appears as if containment will be the most efficient corrective measure. Bench scale studies, literature searches, and vendor information are needed to design a suitable barrier. The remaining corrective measures evaluated are long term remediation projects, would be complicated to implement, and have a lower reliability. Additionally, other corrective measures may be used to reduce the toxicity of soil and groundwater contamination within the contained area. A detailed evaluation of all corrective measures, including projected costs and subsequent environmental impacts of each, will be the focus of the Corrective Measures Study.

**FINAL REPORT
CWM CHEMICAL SERVICES, INC.
CHICAGO INCINERATOR FACILITY
DRAFT RCRA FACILITY INVESTIGATION REPORT
PART THREE
INVESTIGATION ANALYSIS
FEBRUARY 1995**

Dames & Moore No. 13963-055

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1.0 DATA ANALYSIS

This data analysis section is intended to provide sufficient quality and quantity information about the investigation data to describe the nature and extent of contamination, sources and migration pathways, potential threats to human health & the environment and to determine the need for a corrective measures study. The nature and extent of contamination is described more fully in Part One, Section 4.0 of this report.

The original waste management units no longer exist and the approved technical approach to the RFI is a "Facility-wide" investigation of the entire pier area. This investigation involved the characterization of fill material comprising the pier, groundwater flows within the fill, lake waters, sediment and low permeability material underlying the fill.

Part One, Section 2.0 of this report defines in detail the facility Environmental Setting. In general, the facility is constructed upon fill overlying fine grained low permeability material which behaves as a barrier to vertical contaminant migration. Groundwater flows within the fill discharge into Lake Calumet.

2.0 PROTECTION STANDARDS

2.1 Groundwater Protection Standards

The following applicable, relevant and appropriate requirements (ARARs) could apply to the release of hazardous constituents to ground waters or surface waters.

- Title 35, Illinois Administrative Code Subtitle F, Subpart D, 620.420, Groundwater Quality.
- Title 35, Illinois Administrative Code, Section 302, Subpart D, Standards for Secondary Contact Waters.
- Title 35, Illinois Administrative Code Section 611.310, 611.311, and 724.194.
- EPA National Primary Drinking Water Standard, 40 CFR 141 and 142.
- EPA Ambient Water Quality Criteria for Protection of Human Health.

The specific Appendix IX constituents found in the groundwater during the facility investigation and the standards specific to each constituent are shown on Table 2-1.

2.1.1 Background Groundwater Quality

Four RFI groundwater monitoring wells were used to establish background groundwater constituent levels (G307, G334, G343, G347). These wells are located along the east side of the property, inside the property boundary and are considered upgradient of the facility, based upon groundwater flow conditions established in this investigation. These wells are all screened in the fill material, which is the uppermost water bearing unit. Background ranges of detected Appendix IX constituents from Phase I and Phase II groundwater sampling events are listed in

Table 2-1 along with state and national drinking water standards and ambient water quality protection guidance concentrations.

2.2 Alternate Concentration Limits

The Lake Calumet area has a long history of industrial activity. In 1987 the Illinois Legislative Joint Committee on Hazardous Waste in the Lake Calumet Area, reviewed the area's pollution problems and described early waste disposal practices: "Originally, the plant operators simply poured their industrial wastes into the lakes and rivers; in fact, one of the major attractions of the area was easy access to waste disposal. As industrial activity in the Calumet area increased, so did uncontrolled dumping of waste" (1). The Committee found that "Lake Calumet is affected not only by hazardous waste, but also air, soil, and water pollution and the growing crisis of solid waste management." Also noted were the presence of several legal and illegal waste disposal sites and contamination in soil, water, and aquatic sediments of the region.

Many technical studies of the region have documented concerns related to water pollution in the Lake Calumet area. A 1965 U.S. Department of Health, Education, and Welfare study described serious pollution problems from sewage treatment plant discharges and industrial discharges of oily waste, pickle liquors, ammonia, cyanide, and phenolic materials. All of the streams of the Calumet area were described as polluted and contaminated by waste that differed only in the degree and the nature of the pollutants (2).

It is within this contaminated regional environment that the facility investigation was undertaken. Evaluating the contribution of the former waste management activities to the broader regional environmental concerns is a task made difficult by the commonality of the contaminants. It is impractical to expect that restoring a small segment of this regional environment to original conditions would have an identifiable impact on the region.

TABLE 2-1
BACKGROUND CONCENTRATION AND ARARs CONCENTRATION LIMITS

Detected Parameters in Groundwater		Background Concentration Range ¹ ** mg/L	Title 35 Illinois Administrative Code MCL mg/L			Federal Drinking Water ⁵ MCL mg/L	Federal Drinking Water MCLG mg/L	Ambient Water Quality Criteria mg/L		
			620 ²	302 ³	611 ⁴			For Protection of Human Health ⁶	For Protection of Aquatic Life	
									Acute	Chronic
1	1,1,1-Trichloroethane	ND	NA	NA	0.20	0.20	0.2	1,000	NA	NA
2	1,1,2-Trichloroethane	ND	NA	NA	NA	0.0005	0.003	0.042	9.4	9.4
3	1,1-Dichloroethane	ND	NA	NA	NA	NA	NA	NA	NA	NA
4	1,1-Dichloroethylene	ND	0.035	NA	0.007	0.007	0.007	0.0019 ^a	11 ^a	NA
5	1,2-Dichlorobenzene	ND	NA	NA	NA	NA	NA	NA	11 ^b	NA
6	1,2-Dichloroethane	ND	0.025	NA	0.005	0.005	0	0.24	110	20
7	1,2-Trans-dichloroethylene	ND	0.5	NA	NA	0.1	0.1	0.0019 ^a	1.1 ^a	0.6 ^a
8	1,3-Dichlorobenzene	ND	1.5	NA	NA	NA	NA	NA	NA	NA
9	1,4-Dichlorobenzene	ND	0.375	NA	0.075	0.075	NA	NA	NA	NA
10	1,4-Dioxane	*0.0827	NA	NA	NA	NA	NA	NA	NA	NA
11	2,3,4,6-Tetrachlorophenol	ND	NA	NA	NA	NA	NA	NA	NA	NA
12	2,4,5-Trichlorophenol	ND	NA	NA	NA	NA	NA	NA	NA	NA
13	2,4,6-Trichlorophenol	*0.0090	NA	NA	NA	NA	NA	0.0036	0.97	0.97
14	2,4-Dichlorophenol	0.0046-0.0204	NA	NA	NA	NA	NA	NA	2.0	0.3
15	2,4-Dimethylphenol	*0.0050	NA	NA	NA	NA	NA	NA	2.1	2.1
16	2,6-Dichlorophenol	ND	NA	NA	NA	NA	NA	NA	NA	NA

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Detected Parameters in Groundwater		Background Concentration Range ¹ ** mg/L	Title 35 Illinois Administrative Code MCL mg/L			Federal Drinking Water ³ MCL mg/L	Federal Drinking Water MCLG mg/L	Ambient Water Quality Criteria mg/L		
			620 ²	302 ³	611 ⁴			For Protection of Human Health ⁵	For Protection of Aquatic Life	
						Acute	Chronic			
17	2-Chlorophenol	*0.0085	NA	NA	NA	NA	NA	NA	4.3	2.0
18	2-Methylnaphthalene	ND	NA	NA	NA	NA	NA	NA	NA	NA
19	2-Nitrophenol	*0.0081	NA	NA	NA	NA	NA	NA	0.23	0.15
20	Acenaphthene	ND	NA	NA	NA	NA	NA	NA	1.7	0.5
21	Acetone	0.0117-0.0237	NA	NA	NA	NA	NA	NA	NA	NA
22	Acetonitrile	*0.0090	NA	NA	NA	NA	NA	NA	NA	NA
23	Acetophenone	ND	NA	NA	NA	NA	NA	NA	NA	NA
24	Acrolein	ND	NA	NA	NA	NA	NA	0.78	0.068	0.021
25	Aniline	ND	NA	NA	NA	NA	NA	NA	NA	NA
26	Anthracene	ND	NA	NA	NA	NA	NA	NA	NA	NA
27	Antimony	ND	NA	NA	NA	0.01	0.003	45	9.0	1.6
28	Arsenic	0.0300-0.1300	0.2	1.0	0.05	0.05	0.05	0.000018	0.8	0.048
29	Barium	0.0250-1.0000	2.0	5.0	1.0	2.0	2.0	NA	NA	NA
30	Benzene	ND	0.025	NA	0.005	0.005	0	0.041	5.3	NA
31	Benzo(a)anthracene	ND	NA	NA	NA	0.0001	0	NA	NA	NA
32	Benzo(a)pyrene	ND	NA	NA	NA	0.0002	0	NA	NA	NA
33	Benzo(b)fluoranthene	ND	NA	NA	NA	0.0002	0	NA	NA	NA
34	Benzo(ghi)perylene	ND	NA	NA	NA	NA	NA	NA	NA	NA

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Detected Parameters in Groundwater			Background Concentration Range ¹ ** mg/L	Title 35 Illinois Administrative Code MCL mg/L			Federal Drinking Water ² MCL mg/L	Federal Drinking Water MCLG mg/L	Ambient Water Quality Criteria mg/L		
				620 ²	302 ³	611 ⁴			For Protection of Human Health ⁶	For Protection of Aquatic Life	
										Acute	Chronic
35	Benzyl alcohol		ND	NA	NA	NA	NA	NA	NA	NA	
36	Beryllium		0.0019-0.0085	NA	NA	NA	0.004	0	0.00012	0.1	0.0053
37	Cadmium		0.0270-0.0600	0.05	0.15	0.010	0.005	0.005	NA	0.0039	0.0011
38	Carbon disulfide		ND	NA	NA	NA	NA	NA	NA	NA	NA
39	Chlorobenzene		ND	NA	NA	NA	NA	NA	NA	NA	NA
40	Chloroform ^c		ND	NA	NA	NA	0.1	0	0.018	28.0	1.2
41	Chromium	Hexavalent	0.0150-0.2100	1.0	0.3	0.05	0.1 (total)	0.1 (total)	3,433	0.016	0.011
		Trivalent			1.0					1.7	0.2
42	Chrysene		ND	NA	NA	NA	0.0002	0	NA	NA	NA
43	Cobalt		0.0300-0.1700	1.0	NA	NA	NA	NA	NA	NA	NA
44	Copper		0.0220-0.3500	0.65	1.0	5.0	0.2 ^d	NA	NA	0.018	0.012
45	Cyanide, Total		ND	0.6	0.10	0.2	0.20	0.2	NA	0.02	0.00052
46	Dichlorodifluoromethane		ND	NA	NA	NA	NA	NA	NA	NA	NA
47	Di-n-butyl phthalate		ND	NA	NA	NA	NA	NA	0.77	NA	NA
48	Ethylbenzene		ND	1.0	NA	NA	0.7	0.7	3.28	32	NA
49	Fluoranthene		ND	NA	NA	NA	NA	NA	0.054	3.9	NA
50	Fluorene		ND	NA	NA	NA	NA	NA	NA	NA	NA
51	Hexachlorobenzene		ND	NA	NA	NA	0.001	0	0.00000074	NA	NA

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Detected Parameters in Groundwater		Background Concentration Range ¹ ** mg/L	Title 35 Illinois Administrative Code MCL mg/L			Federal Drinking Water ⁵ MCL mg/L	Federal Drinking Water MCLG mg/L	Ambient Water Quality Criteria mg/L		
			620 ²	302 ³	611 ⁴			For Protection of Human Health ⁶	For Protection of Aquatic Life	
									Acute	Chronic
52	Indeno(1,2,3-c,d)pyrene	ND	NA	NA	NA	0.0004	0	NA	NA	NA
53	Isobutyl alcohol	*0.0212	NA	NA	NA	NA	NA	NA	NA	NA
54	Lead	0.1100-0.8200	0.1	0.1	0.05	0.015 ^d	0	NA	0.08	0.0032
55	Mercury	0.0004-0.0008	0.01	0.0005	0.002	0.002	0.002	0.000146	0.0024	0.000012
56	Methyl ethyl ketone	ND	NA	NA	NA	NA	NA	NA	NA	NA
57	Methyl-iso-butyl ketone	ND	NA	NA	NA	NA	NA	NA	NA	NA
58	Methylene chloride	0.0061-0.0229	NA	NA	NA	0.005	0	NA	NA	NA
59	Naphthalene	ND	NA	NA	NA	NA	NA	NA	NA	NA
60	Nickel	0.0520-0.2700	2.0	1.0	NA	0.1	0.1	0.1	1.4	0.16
61	Nitrobenzene	ND	NA	NA	NA	NA	NA	NA	27	NA
62	Pentachlorophenol	0.0091	0.005	NA	NA	0.001	0	NA	0.02	0.013
63	Phenanthrene	ND	NA	NA	NA	NA	NA	NA	NA	NA
64	Phenol	ND	0.1	0.3	NA	NA	NA	NA	10	2.5
65	Phorate		NA	NA	NA	NA	NA	NA	NA	NA
66	Pyrene	ND	NA	NA	NA	NA	NA	NA	NA	NA
67	Pyridine	ND	NA	NA	NA	NA	NA	NA	NA	NA
68	Selenium	*0.0330	0.05	1.0	0.01	0.05	0.05	0.01	0.26	0.035
69	Silver	.01700-0.0320	NA	1.1	0.05	(0.1) ^e NA	NA	0.05	0.0041	0.00012

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			620 ²	302 ³	611 ⁴			For Protection of Human Health ⁶	For Protection of Aquatic Life	
									Acute	Chronic
70	Sulfide, As S	0.3000-2.3000	NA	NA	NA	NA	NA	NA	NA	NA
71	Styrene	ND	0.5	NA	NA	0.1	0.1	NA	NA	NA
72	Tetrachloroethylene	ND	NA	NA	NA	0.005	0	0.0089	5.2	0.84
73	Thallium	ND	NA	NA	NA	0.002	0.0005	0.048	1.4	0.04
74	Tin	*0.0520	NA	NA	NA	NA	NA	NA	NA	NA
75	Toluene	ND	NA	NA	NA	1.0	1.0	424	17	NA
76	Trichloroethylene	ND	0.025	NA	0.005	0.005	0	0.081	45	21
77	Vanadium	0.0890-0.3400	NA	NA	NA	NA	NA	NA	NA	NA
78	Vinyl chloride	ND	0.01	NA	0.002	0.002	0	0.53	NA	NA
79	Zinc	0.0950-1.2000	10.0	1.0	5.0	(5.0) ^e NA	NA	NA	0.13	0.11
80	bis(2-Ethylhexyl)phthalate	*0.01270	NA	NA	NA	NA	NA	15.0	NA	NA
81	m + p-Cresols	ND	NA	NA	NA	***10	NA	NA	NA	NA
82	m-Xylene	ND	NA	NA	NA	***10	NA	NA	NA	NA
83	o + p-Xylenes	ND	NA	NA	NA	***10	NA	NA	NA	NA
84	o-Cresol	ND	NA	NA	NA	NA	NA	NA	NA	NA
85	o-Toluidine	ND	NA	NA	NA	NA	NA	NA	NA	NA
86	p-Chloro-m-cresol	*0.0062	NA	NA	NA	NA	NA	NA	NA	NA
87	p-Chloroaniline	ND	NA	NA	NA	NA	NA	NA	NA	NA

NOTES:

1. Range of detected parameters from wells #G307, G334, G343, G347 along the east boundary of the property and considered upgradient background conditions.
2. Title 35 Illinois Administrative Code (I.A.C.), Subtitle F, Subpart D, 620.420, Groundwater Quality Standards for Class II Groundwater.
3. Title 35 I.A.C., Part 302, Subpart D, Standards For Secondary Contact Waters.
4. Title 35 I.A.C., 611.300, 611.310, 611.311.
5. EPA National Primary Drinking Water Standard 40 CFR 141.
6. For protection of human health associated with the toxic affects of ingesting organisms, USEPA Water Quality Criteria Gold Book.
- ND Not detected above detection limit.
- NA Not available
- * Parameter detected once in background wells.
- ** Values which were reported in $\mu\text{g/L}$ are expressed in mg/L for purposes of comparison to state and federal standards.
- *** Value is for total xylenes.
- a Value is for dichloroethylenes.
- b Value is for dichlorobenzenes.
- c Total trihalomethanes.
- d 90th Percentile Action Levels.
- e Secondary MCL.

2.3 Establishing Preliminary Remediation Goals for Compounds Detected in Non-potable Groundwater

In accordance with Title Administrative Code, Subtitle F, Part 620, Illinois EPA has concurred that groundwater occurring within the fill at the CWMCS facility is Class II, General Resource Groundwater, and is not potable. Consistent with this classification, preliminary remediation goals are not based on human health effects associated with the use of this groundwater as a drinking water source or for domestic or agricultural purposes (e.g., washing or irrigation of home-raised crops). Since groundwater within the fill is in hydraulic connection with Lake Calumet, preliminary remediation goals for groundwater are based on other beneficial uses including: (1) protection and propagation of fish and aquatic life; (2) the protection of wildlife that may consume the water; and (3) recreation (EPA, 1988).

Contaminants contained within the shallow groundwater within the pier may be ultimately conveyed into Lake Calumet. Most of the contaminants within the pier have been present for more than 20 years and efforts have been initiated to remove portions of the contaminants through remediation projects. No new waste has been added to the SWMUs closed as part of the pier restoration project and as a result, contaminant levels within the fill are not increasing over time. For these reasons, future contaminant levels in surface water and sediment near the CWMCS pier are not expected to substantially increase over time, and potential current impacts to aquatic receptors inhabiting the lake are assumed to be representative of potential future impacts. Establishment of Preliminary Remediation Goals (PRGs) for groundwater to ensure the protection of aquatic life are not necessary. Potential risks to current ecological receptors known or suspected to occur in Lake Calumet near the CWMCS pier have been quantitatively evaluated in the Ecological Risk Assessment (ERA) prepared for this site. PRGs for surface water and sediments within Lake Calumet will be based on the protection of aquatic life.

Exposures by terrestrial animals that may consume water from Lake Calumet near the CWMCS pier are expected to be minimal. Water fowl, shorebirds, and non-aquatic bird species which are known to occur in the area, tend to feed throughout the Lake Calumet area (not just the area near the CWMCS pier), as well as other water bodies in the area. Although it is possible that waterfowl and shorebirds may search for food in areas of Lake Calumet near the CWMCS site, the home ranges of most species known or suspected to occur in the area are large relative to the area affected by releases from the CWMCS site.

The pier area may serve as a habitat for small mammal species and large mammals may access areas of the pier which are not within the fenced area. Mammals range over adjacent areas of the Lake Calumet area. Given the ubiquitous nature of contamination throughout the area, establishment of PRGs for groundwater based on the protection of terrestrial wildlife is impractical.

The final potential use of Lake Calumet which was considered in this report is recreation. Given the industrial nature of the area, it is unlikely that individuals would use Lake Calumet for recreational purposes (e.g., swimming and water-skiing). Exposures by recreational users of the lake are expected to be minimal because: (1) no recreational swimmers have been observed at any time by site personnel; (2) the water in Lake Calumet contains only about three feet of water; (3) dilution of soluble contaminants in this large body of water is expected to offset chemical inputs from industrial sources around the lake; and (4) Lake Calumet is an industrial waterway developed for the exclusive use of commercial traffic. Thus, it is unlikely that individuals would swim in Lake Calumet at all, much less spend a substantial portion of time swimming in areas near the CWMCS site. Therefore, direct ingestion and dermal contact with surface water and sediment are incomplete pathways of human exposure; hence, the establishment of PRGs based on recreational use of Lake Calumet is not warranted.

3.0 REFERENCES

1. Fitzpatrick, William P. "Contaminants in the Surface Waters of the Lake Calumet Region," Report given at the Lake Calumet area: Environmental Concerns Conference, May 1990, Illinois State Water Survey, Champaign, Illinois.
2. (USHEW) U.S. Department of Health, Education and Welfare, 1965. Report on Pollution of the Waters of the Grand Calumet River, Little Calumet River, Calumet River, Lake Michigan, Wolf Lake, and Their Tributaries, Illinois-Indiana. Division of Water Supply and Pollution Control, Region V, Chicago, IL.